Final Program and Abstract Book

Minnesota Water Resources CONFERENCE

October 17–18, 2017

Saint Paul RiverCentre

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University of Minnesota

Minnesota Water Resources Conference

October 17–18, 2017

Guidebook Mobile App

We encourage you to download the mobile app to enhance your experience at the conference. Personalize your schedule and browse concurrent session and poster abstracts, presenter biographies, exhibitors, and maps, and participate in the conference backchannel by posting on social media (Twitter and Facebook) before and during the conference. The app is compatible with iOS and Android devices. Windows, iPhone 7, and Blackberry users can access the same information via the mobile site. https://guidebook.com/redeem/?next=/guide/94412/

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Social Media: Join the Conversation

We invite you to join the conversation about the Minnesota Water Resources Conference by posting updates on Twitter and Facebook. The course hashtag is **#mnwrc17**: type this hashtag in your tweets/posts to continue the course backchannel, or you may also search Twitter for this hashtag to view the tweets online and keep up with sessions you missed. These social media efforts will help participants network and meet new colleagues prior to and during the course.

CEU/PDH Information:

Conference attendees will receive .675 CEUs/6.75 PDHs for each day of the Minnesota Water Resources Conference. Participants who wish to receive full credit must attend all scheduled hours of the event. Please turn in CEU forms at the registration desk before you leave. PDH forms should be kept for your records.

2017 Water Resources Planning Committee

John Baker, US Department of Agriculture, and Department of Soil, Water, and Climate, UMN
Ann Banitt, US Army Corps of Engineers
Jeff Berg, Minnesota Department of Agriculture
John Bilotta, MN Sea Grant, UMN Extension
Mark Brigham, US Geological Survey
Tina Carstens, Ramsey-Washington Metro Watershed District
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Tracy Fallon, Water Resources Center, UMN
Andrea Hendrickson, Minnesota Department of Transportation
Kimberly Hill, St. Anthony Falls Laboratory, UMN
Karen Jensen, Metropolitan Council
Lucinda Johnson, Natural Resources Research Institute, University of Minnesota
Stephanie Johnson, Mississippi Watershed Management Organization
Cheryel Konate, Water Resources Center, UMN
Ron Leaf, Short Elliott Hendrickson, Inc.
Zack McGough, College of Continuing and Professional Studies, UMN
Salam Murtada, Department of Natural Resources, Division of Waters
Randy Neprash, Minnesota Cities Stormwater Coalition & Stantec
**Jeffrey Peterson,* Water Resources Center, UMN
Amit Pradhananga, Department of Forest Resources, UMN
Shawn Schottler, St. Croix Watershed Research Station
Wayne Sicora, Natural Resource Group
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James Stark, US Geological Survey
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* Committee Co-chairs

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Department of Civil Engineering, University of Minnesota
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Minnesota Sea Grant College Program, University of Minnesota
Natural Resources Research Institute, University of Minnesota

Minnesota Water Resources Conference

October 17–18, 2017

Exhibitors

Mniówe / Water Bar

Mniówe is a place for gathering water. At Mniówe / Water Bar, you can sample drinking waters from around Mnísota (Minnesota) and connect conference themes to conversations about ways we use and interact with water in our daily lives. You can also learn about indigenous philosophies, relationships and practices relating to Mní (water) that have allowed Dakota people to thrive in this area for millennia.

Mniówe is also the indigenized rendition of Water Bar, created in collaboration by Water Bar & Public Studio, Healing Place Collaborative, and Dakhóta lápi Okhódakichiye (Dakota Language Society).

ASCE American Society of Civil Engineers

AE2S

HDR

Bolton & Menk — Real People. Real Solutions.

Momentum Environmental

College of Continuing & Professional Studies, University of Minnesota

County Materials Corporation

Department of Agriculture

Kisters — Data Management Solutions

Houston Engineering

KLJ — Engineering, Reimagined

the Water Main

LimnoPro Aquatic Science

Midwest Floating Island

SRF Consulting Group, Inc. — Engineers Planners Designers

Water Resources Center, University of Minnesota — Driven to Discover℠

Metropolitan Council

ESE Ecosystem Services Exchange — Valuing Conservation

Tech Sales Co.

Water in Motion

StormTrap

Stantec

Tetra Tech

Aquatic Informatics — Faster Analysis. Better Decisions.

moore engineering, inc.

RESPEC

St. Anthony Falls Laboratory, College of Science & Engineering, University of Minnesota

WSB

BrockWhite Construction Materials

StormTree

RMB Environmental Laboratories, Inc

Natural Resources Research Institute, University of Minnesota Duluth — Driven to Discover

RETURNING FEATURES THIS YEAR

Special Session

A Market Approach to Continuous Living Cropping Systems: The Sweet Spot for Water, Wildlife, and Climate

This special session will explore the need for perennial cropping systems and their potential to improve our natural resources. Specific markets examples will be used to illustrate the benefits to water and wildlife, and also policies, technologies, and financial incentives necessary to make these markets profitable.

Presenters will include:

Rich Biske, The Nature Conservancy; *Joe Duggan,* Pheasants Forever; *Brendan Jordan,* Great Plains Institute; *Steve Morse,* Minnesota Environmental Partnership; *Jeff Peterson,* University of Minnesota; *Shawn Schottler,* Science Museum of Minnesota; *Don Wyse,* University of Minnesota–Forever Green Initiative

Exhibitor and Poster Area

The exhibitor and poster area will be set up in a large ballroom again this year, to facilitate networking and discussion with exhibitors and poster authors. Refreshments will be served in this area, along with the Tuesday evening reception.

Call for Committee Members

Are you employed in the private sector and interested in serving on the Water Resources Planning Committee? Do you know someone in the private sector who would be a good committee member? One seat on the committee representing private sector organizations has become vacant. Nominations to fill this position should be sent by email to cceconf3@umn.edu no later than November 17, 2017. The nomination must include a statement of qualifications by the nominee describing his or her education, experience, area of expertise, and reasons for seeking a committee position. Self-nominations are encouraged. The current committee will elect the new member at their December meeting from the nominations received. Once elected to this position, the committee member serves for an indefinite term as long as they remain in the private sector.

This session uses Pigeonhole Live for interactive Q&A

Pigeonhole Live is a simple, interactive mobile website where you can submit questions to speakers via your mobile web device. You can also vote for questions that interest you. Everyone gets to take part in Q&A sessions without running to the microphones. Yes, even if you are a little shy.

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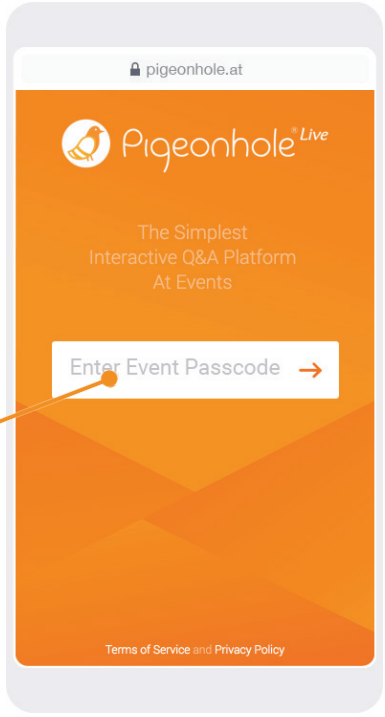
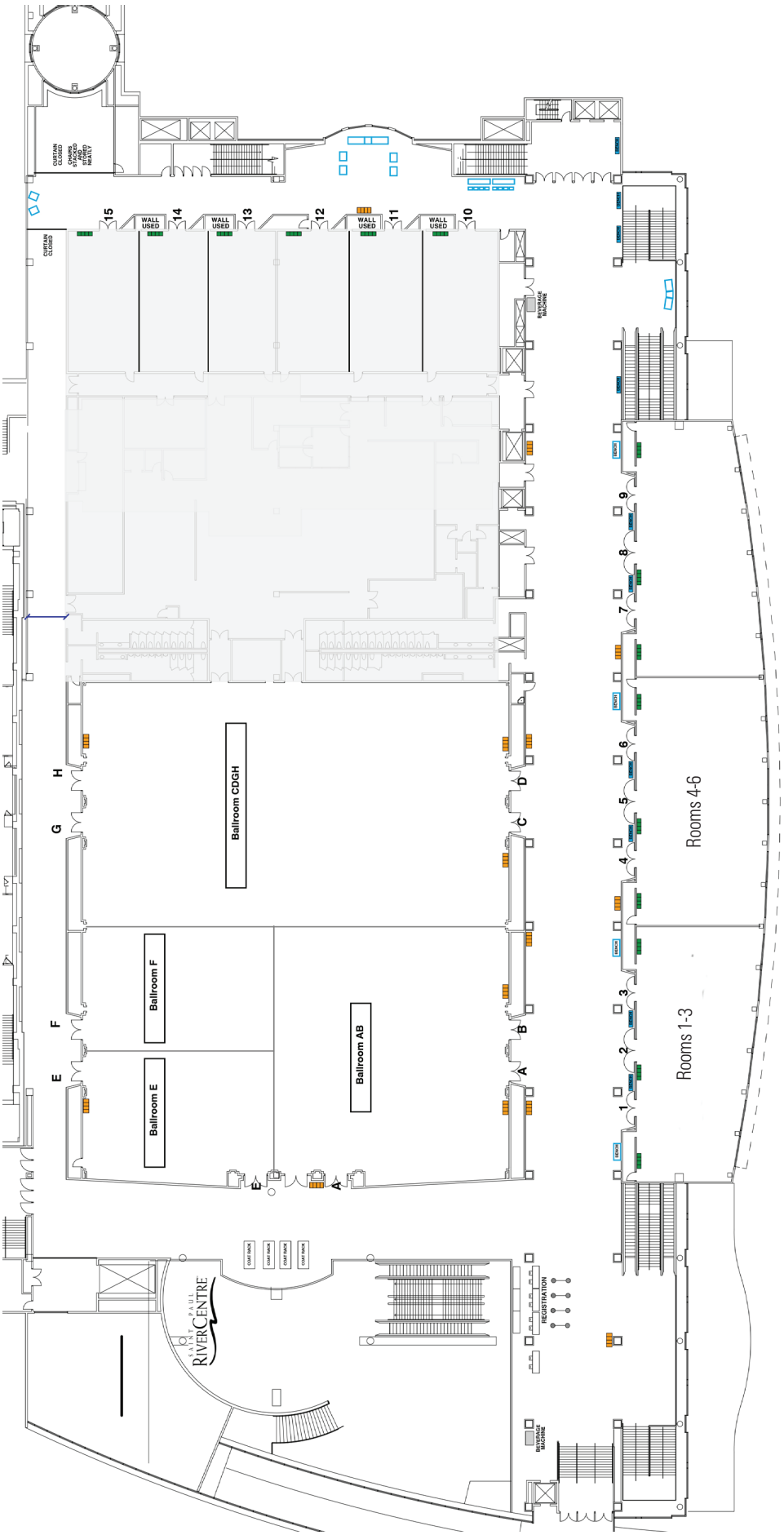
Enter event passcode:

MNWRC17




Ballroom CDGH
Ballroom F
Ballroom E
Ballroom AB
Rooms 4-6
Rooms 1-3
REGISTRATION
RIVERCENTRE
SAINT PAUL

Program Schedule – Tuesday, October 17, 2017

8:00–8:10 a.m. **Welcome Grand Ballroom (CDGH)**
Jeff Peterson, Water Resources Center, University of Minnesota

8:10–8:20 a.m. **Dave Ford Water Resources Award**

8:20–9:30 a.m. **Plenary Session Grand Ballroom (CDGH)**
Communicating Science for Action
Amy Skoczlas Cole, American Public Media

9:30–10:00 a.m. **Break Ballroom AB**

10:00–11:30 a.m. Concurrent Sessions I

Track A Ballroom E

Wetlands—Benefits to All

Moderator: *Katy Thompson,* WSB & Associates

Co-Moderator: *Rick Voigt,* Voigt Consultants, LLC

Monitoring Changes in Minnesota Wetland Area from 2006 to 2014

Steve Kloiber and Doug Norris, Minnesota Department of Natural Resources

Potholes in the Prairie: Defining Wetland Complex Hydrology

Jennifer Gruetzman, United States Fish and Wildlife Service

Modeling Hydrology of Headwater Boreal Watersheds

Jonathan Hess, Scott County Soil and Water Conservation District; *John Nieber,* University of Minnesota; *Stephen Sebestyen,* United States Forest Service

Six Mile Marsh: Total Phosphorus Sink or Soluble Phosphorus Source?

Brian Beck, Wenck Associates, Inc.; *Kelly Dooley,* Minnehaha Creek Watershed District; *Sarah Nalven and Joe Bischoff,* Wenck Associates; *Anna Brown,* Minnehaha Creek Watershed District

Track B Ballroom F

Stormwater: Iron Enhanced Practices

Moderator: *John Bilotta,* University of Minnesota

Co-Moderator: *John Gulliver,* University of Minnesota

Iron Filings Application to Reduce Internal Phosphorus Loading in Lakes

Poornima Natarajan, Saint Anthony Falls Laboratory, University of Minnesota; *John Gulliver and William Arnold,* University of Minnesota

Iron-Enhanced Sand Filter Performance for Reducing Phosphorus from a Regional Stormwater Pond: Roseville, MN

Maddie Vargo, Bob Fossum, and Britta Suppes, Capitol Region Watershed District

Performance of Iron-Enhanced Sand Filters: Results from Laboratory, Urban, and Agricultural Studies

Andy Erickson and John Gulliver, St. Anthony Falls Laboratory, University of Minnesota; *Pete Weiss,* Valparaiso University

Using Innovative Iron-Enhanced BMPs to Maximize Phosphorus Removal

Tim Olson and Bill Douglass, Bolton & Menk, Inc.

Track C Rooms 1-3

Adapting to Climate Change

Moderator: *Tina Carstens,* Ramsey-Washington Metro Watershed District

Co-Moderator: *Ann Banitt,* United States Army Corps of Engineers

3D Modeling and Prediction of Coolwater Fish Habitat Under Changing Climate

Shahram Missaghi, St. Anthony Falls Laboratory, University of Minnesota and University of Minnesota Extension; *Miki Hondzo and William Herb,* Saint Anthony Falls, University of Minnesota

Climate and Land Use Changes Impact on Nitrogen Concentrations and Nitrogen Loads in the Minnesota River

Nathaniel Baeumler and Satish Gupta, University of Minnesota

Protecting Two-Story Lakes: A Battle Against Phosphorus and Climate Change

Hans Holmberg, Dendy Lofton, and Ben Crary, LimnoTech; *Gary Pulford,* Courte Oreilles Lake Association; *Dan Tyrolt,* Lac Courte Oreilles Conservation District

Engagement Strategies to Plan for Climate Resilience at the Community and Watershed Scale

Leslie Yetka, Freshwater Society; *Claire Bleser,* Riley Purgatory Bluff Creek Watershed District; *Erica Sniegowski,* Nine Mile Creek Watershed District; *Fred Rozumalski,* Barr Engineering Company

Track D Rooms 4-6

Sediment & Phosphorus

Moderator: *Gene Soderbeck,* Minnesota Pollution Control Agency

Co-Moderator: *Mark Brigham,* United States Geological Survey

Tackling Soluble Phosphorus in Agricultural Watersheds

Rebecca Carlson, Wenck Associates, Inc.; *Cole Loewen,* Clearwater River Watershed District

Sediment-Phosphorus Interactions and Their Implications for Watershed Management in Agricultural Landscapes

Anna Baker, Jacques Finlay, Diana Karwan, Tessa Belo, and Water Atkins, University of Minnesota; *Karen Gran,* University of Minnesota Duluth; *Daniel Engstrom,* St. Croix Watershed Research Station

Suspended-Sediment Concentrations, Bed Load, Particle Sizes, Surrogate Measurements, and Annual Sediment Loads for Selected Sites in the Lower Minnesota River Basin, Water Years 2011 Through 2016

Joel Groten, United States Geological Survey Minnesota Water Science Center; *Christopher Ellison,* United States Geological Survey; *Jon Hendrickson,* United States Army Corps of Engineers

Wind Erosion: Does it Matter for Water Quality?

Kris Guentzel, Drew Kessler, and Mark Deutschman, Houston Engineering, Inc.

*Underline indicates onsite presenter

Program Schedule – Tuesday, October 17, 2017 (continued)

11:30 a.m.–12:15 p.m. Lunch Grand Ballroom (CDGH)

12:15–1:00 p.m. Luncheon Presentation

Water Quality and Agriculture
Greg Page, Retired Chairman and CEO, Cargill, Incorporated

1:15–2:45 p.m. Concurrent Sessions II

Track A Ballroom E

Lakes—Phosphorus Loading

Moderator: *Gene Soderbeck,* Minnesota Pollution Control Agency

Co-Moderator: *Bill Douglass*, Bolton & Menk, Inc.

Predicting Responses of Lakes to Phosphorus Loading by Characterizing Efficiency of P Recycling in Sediments

Sergei Katsev, Large Lakes Observatory, University of Minnesota Duluth

Why Zebra Mussels Are Crashing in Lake Minnetonka and What It Means for Other Lakes

Steve McComas, Blue Water Science; *Eric Fieldseth,* Minnehaha Creek Watershed District

Assessment of Lake of the Woods' Internal Phosphorus Loading

Geoff Kramer and Bruce Wilson, RESPEC Consulting and Services; *Jesse Anderson and Cary Hernandez,* Minnesota Pollution Control Agency

Track B Ballroom F

Water Reuse and Conservation

Moderator: *Stew Thornley*, Minnesota Department of Health

Co-Moderator: *Ron Leaf*, Kimley-Horn & Associates

Advancing Safe and Sustainable Water Reuse in Minnesota

Anita Anderson, Minnesota Department of Health

Stormwater Reuse in Carver County: An Innovative Approach to Reducing Pollutant Loads to Water Resources

Tim Sundby, Carver County Water Management Organization

Northwood Lake Stormwater Improvements

Tyler Johnson and Chris Long, Stantec Consulting Services; *Bernie Weber and Megan Albert,* City of New Hope

New Water Conservation Reporting System

Carmelita Nelson, Minnesota Department of Natural Resources; *Leo Steidel,* Energy Savings Platform

Track C Rooms 1-3

Wastewater Treatment

Moderator: *John Baker*, United States Department of Agriculture

Co-Moderator: *Karen Jensen*, Metropolitan Council

A History of "Conventional" Wastewater Treatment" in Response to New Water Quality Standards in Minnesota

Scott Kyser, Minnesota Pollution Control Agency

Clean Water Funding and the Cost of Wastewater Treatment in Minnesota

Baishali Bakshi and Joel Peck, Minnesota Pollution Control Agency

Nanoselenium Sponge Technology for Mercury Removal from Water

John Brockgreitens, Snober Ahmed, and Abdennour Abbas, University of Minnesota

Rapid Removal of Phosphate from Water Using a Nanoiron Sponge

Fatemeh Heidari, John Brockgreitens, and Abdennour Abbas, University of Minnesota

Track D Rooms 4-6

Special Session

Moderator: *Shawn Schottler*, St. Croix Watershed Research Station

Co-Moderator: *Jeffrey Peterson*, University of Minnesota

A Market Approach to Continuous Living Cropping Systems: The Sweet Spot for Water, Wildlife, and Climate

This special session will explore the need for perennial cropping systems and their potential to improve our natural resources. Specific markets examples will be used to illustrate the benefits to water and wildlife, and also policies, technologies, and financial incentives necessary to make these markets profitable.

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Agenda

A. 1:15–1:30
Introduction: Perennial Crops as a Water, Wildlife, and Climate Remedy

B. 1:30–2:15
The Need for and Potential of Perennial Cropping Systems—Three Perspectives: Water Quality, Wildlife Habitat, Carbon Storage

C. 2:15–2:45
Example Market Scenarios

*Underline indicates onsite presenter

Program Schedule – Tuesday, October 17, 2017 (continued)

2:45–3:15 p.m. **Break** **Ballroom AB**

3:15–4:45 p.m. Concurrent Sessions III

Track A Ballroom E

Lakes—Miscellaneous

Moderator: *Lorin Hatch*, WSB & Associates

Co-Moderator: *Gene Soderbeck*, Minnesota Pollution Control Agency

Canvasback Ducks, Wild Celery, and Nutrient Regulation in Large Shallow Water Lakes

Stephen Thomforde, Dakota County Technical College

New Evidence of Algal Toxins in Lake Kabetogama, Voyageurs National Park, Northern Minnesota

Victoria Christensen and Erin Stelzer, United States Geological Survey Minnesota Water Science Center; *Ryan Maki*, National Park Service

Lake Color Across Seasons, Years and Decades: Cross-Scale Temporal Variability in Minnesota Lake Chromophoric Dissolved Organic Matter from Field and Remote Sensing Data

Claire Griffin, Patrick Brezonik, Jacques Finlay, Leif Olmanson, Benjamin Allen, and Raymond Hozalski, University of Minnesota

Moving Toward Near Real-Time Water Quality Measurements in Minnesota Using New Landsat and Sentinel Satellite Data

Claire Griffin, Patrick Brezonik, Marvin Bauer, Jacques Finlay, Leif Olmanson, Benjamin Allen, and Raymond Hozalski, University of Minnesota

Track B Ballroom F

Water Management from the Metro's Perspective

Moderator: *Stephanie Johnson*, Mississippi Watershed Management Organization

Co-Moderator: *Andrea Hendrickson*, Minnesota Department of Transportation

35 Years of Failures and Success: Impact of the Metropolitan Surface Water Management Act

Steve Woods, Freshwater Society

Revitalizing Stormwater: Incorporating Ultra-Urban BMPs in the Jackson Street Reconstruction

Patrick Sejkora and Chad Setterholm, Short Elliott Hendrickson, Inc.; *Cindy Zerger*, Toole Design Group

Adaptive Project Execution Under Challenging Seasonal Climatic Conditions

Kyle Axtell, Rice Creek Watershed District; *Dennis McAlpine*, Houston Engineering, Inc.

Solving a TMDL Problem: Keller Lake WQ Improvements

Jacob Newhall, WSB and Associates; *Daryl Jacobson*, City of Burnsville

Track C Rooms 1-3

Using Bioreactors for Water Quality Enhancement

Moderator: *Lucinda Johnson*, Natural Resources Research Institute, University of Minnesota

Co-Moderator: *Jeff Berg*, Minnesota Department of Agriculture

Bioreactors and Saturated Buffer—Making an Impact on Drainage and Water Quality

Chuck Brandel and Mark Origer, ISG

Novel Design and Field Performance of Phosphorus-Sorbing and Denitrifying Bioreactors

Andry Ranaivoson, Jeffrey Strock, Marta Roser, and David Mulla, University of Minnesota; *Gary Feyereisen and Kurt Spokas*, United States Department of Agriculture, Agricultural Research Service

Nitrate Removal from Agricultural Runoff in Denitrifying Bioreactors

Nadine Hacksaw, Michael Brown, Lori Krider, Bruce Wilson, and Sebastian Behrens, University of Minnesota

Enhanced Microbial Sulfate Removal Through a Novel Electrode-Integrated Bioreader

Daniel Takaki, Tobin Deen, and Chan Lan Chun, Natural Resources Research Institute, University of Minnesota Duluth; *Daniel S. Jones*, University of Minnesota

*Underline indicates onsite presenter

Track D Rooms 4-6

Special Session (continued)

D. 3:15–4:00
Example Market Scenarios continued

E. 4:00–4:10
Synthesis

F. 4:10–4:45
Panel Discussion

4:45 – 5:45 **Reception and Poster Session** **Ballroom AB**

Program Schedule – Wednesday, October 18, 2017

8:00–8:10 a.m. **Welcome Grand Ballroom (CDGH)**
Greg Wilson, Barr Engineering Company

8:10–9:30 a.m. **Plenary Session**
Water Quality and Microorganisms: Protecting Recreation and Public Health
Mike Sadowsky, University of Minnesota

9:30–10:00 a.m. **Break Ballroom AB**

10:00–11:30 a.m. Concurrent Sessions IV

Track A Ballroom E

Alteration and Conservation

Moderator: *Ann Banitt*, United States Army Corps of Engineers

Co-Moderator: *Salam Murtada*, Minnesota Department of Natural Resources

A Framework for Addressing Altered Hydrology

Timothy Erickson, Mark Deutschman, and Drew Kessler, Houston Engineering, Inc.

The Minnesota Public Drainage Manual—A Guide to Administering Minnesota Statutes, Chapter 103E Publically Administered Privately Owned Drainage Systems

Tim Gillette, Minnesota Board of Water and Soil Resources

Evolution of the Agricultural BMP Handbook for Minnesota

Christian Lenhart and Brad Gordon, University of Minnesota; *Margaret Wagner*, Minnesota Department of Agriculture; *Walter Esenaur*, SRF Consulting Group, Inc.

Improving the Effectiveness of Conservation in the Le Sueur River Basin

Amy Hansen, St. Anthony Falls Laboratory, University of Minnesota; *Christine Dolph, Jacques Finlay, and Brent Dalzell*, Peter Hawthorne, Eric Lonsdorf, University of Minnesota; *Efi Foufoula-Georgiou*, University of California–Irvine; *Patrick Belmont and Peter Wilcock*, Utah State University; *Cathy Kling*, Iowa State University; *Sergey Rabotyagov*, University of Washington; *Karen Gran*, University of Minnesota Duluth

Track B Ballroom F

Equity, Value, and Capacity—Building for Water Resources

Moderator: *Karen Jensen*, Metropolitan Council

Co-Moderator: *Tina Carstens*, Ramsey-Washington Metro Watershed District

Equity and Justice in Organizations Responsible for the Stewardship of Water Resources

Marie Donahue and Vanessa Voller, University of Minnesota; *Lark Weller*, National Park Service Mississippi National River and Recreation Area

What Is Clean Water Worth? Accounting for the True Value of Water in Minnesota

Bonnie Keller, University of Minnesota

Building Capacity and Competence: It's Not All About Money

Paul Nelson, Scott County; *Mae Davenport,* University of Minnesota; *Troy Kuphal*, Scott Soil and Water Conservation District

Blooming Alleys for Clean Water: Addressing Impaired Waters through Citizen Engagement

Laura Scholl and Rich Harrison, Metro Blooms

Track C Rooms 1-3

Groundwater/Surface Water

Moderator: *Gene Soderbeck*, Minnesota Pollution Control Agency

Co-Moderator: *Jim Stark*, United States Geological Survey

Who Uses the Municipal Groundwater Supply in the North and East Groundwater Management Area?

Mick Jost, Minnesota Technical Assistance Program, University of Minnesota; *Miriam Yee,* (formerly) Minnesota Technical Assistance Program, University of Minnesota

Groundwater-Surface Water Exchange Dynamics Following a Channel Reconfiguration Project: Stewart River, MN

Larissa Scott and Karen Gran, University of Minnesota Duluth; *Lucinda Johnson*, National Resources Research Institute, University of Minnesota

Streambank Stabilization Project: Landowner Perspectives

Barbara Liukkonen, Retired, University of Minnesota

Simulation and Assessment of Groundwater Flow and Surface-Water Exchanges in Lakes of the Northeast Twin Cities Metropolitan Area, Minnesota, 2003–2013

Perry Jones, United States Geological Survey Minnesota Water Science Center; *Jared Trost, Catherine Christenson, and Aliesha L. Diekoff,* United States Geological Survey; *Jason Roth*, United States Department of Agriculture, Natural Resources Conservation Service

Track D Rooms 4-6

Chemicals of Concern

Moderator: *Kimberly Hill*, St. Anthony Falls Laboratory, University of Minnesota

Co-Moderator: *Randy Neprash*, Stantec Consulting Services, Inc.

Estrone and Temperature Interactions: Effects on the Predator-Prey Relationship in Freshwater Fish

Victoria Korn, Heiko Schoenfuss, and Jessica Ward, St. Cloud State University

Micropollutants in Groundwater and Soil at Wastewater Land Application Sites

Aleisha Krall and Sarah Elliott, United States Geological Survey Minnesota Water Science Center; *Melinda Erickson*, United States Geological Survey; *Byron Adams*, Minnesota Pollution Control Agency

PFAS Trends in Environmental Media and Facility Management Considerations to Limit Future Liabilities

Shalene Thomas and Hannah Albertus-Benham, Amec Foster Wheeler

Pollutant Stress in the Maumee River: Impacted Physiology and Reproduction in Fathead Minnows (Pimephales promelas) and Sunfish (Lepomis spp.)

Nicholas Cipoletti and Heiko Schoenfuss, St. Cloud State University

*Underline indicates onsite presenter

Program Schedule – Wednesday, October 18, 2017 (continued)

11:30 a.m.–12:15 p.m. **Lunch** **Grand Ballroom (CDGH)**

12:15–1:00 p.m. **Luncheon Presentation**

Tribal Water Resources Issues
Nancy Schuldt, Fond du Lac Environmental Program

1:15–2:45 p.m. Concurrent Sessions V

Track A Ballroom E

Modeling in Agricultural Watersheds

Moderator: *Jeff Berg*, Minnesota Department of Agriculture

Co-Moderator: *Marcey Westrick*, Board of Water and Soil Resources

Resilience Under Accelerated Change (REACH): Modeling Tradeoffs in Water Quality, Ecosystem Services, and Conservation in the Minnesota River Basin

Christy Dolph, Jacques Finlay, Brent Dalzell, and Amy Hansen, University of Minnesota; *Efi Foufoula-Georgiou*, University of California–Irvine; *Patrick Belmont and Peter Wilcock*, Utah State University; *Cathy Kling*, Iowa State University; *Sergey Rabotyagov*, University of Washington; *Karen Gran*, University of Minnesota Duluth; *Se Jong Cho*, Johns Hopkins University

Evaluating the Benefits of Cover Crop Applications on Surface Runoff, Erosion, and Water Quality Using the Gridded Surface Subsurface Hydrological Analysis (GSSHA) Model

Salam Murtada, Minnesota Department of Natural Resources, Ecological and Water Resources

Modeling Effects of Nitrogen BMPs on Nitrate Efflux from Small Agricultural Watersheds in the South Branch of the Root River Watershed

Mark Greve, John Nieber, and David Mulla, University of Minnesota; *Heidi Peterson, and Kevin Kuehner*, Minnesota Department of Agriculture

Watershed Model Calibration with HSPEXP+1.31: A Case Study for the Snake River Watershed

Anurag Mishra, Brian Bicknell, Paul Duda, and Tony Donigan, RESPEC Consulting and Services

*Underline indicates onsite presenter

Track B Ballroom F

Contaminated Runoff and Mitigation Strategies

Moderator: *Bill Douglass*, Bolton & Menk, Inc.

Co-Moderator: *Tina Carstens*, Ramsey-Washington Metro Watershed District

Assessing BMP Removal of Contaminants of Emerging Concern in Urban Stormwater

Richard Kiesling, United States Geological Survey; *David Fairbairn*, Minnesota Pollution Control Agency; *Sarah Elliott*, United States Geological Survey Minnesota Water Science Center; *Mark Ferrey*, Minnesota Pollution Control Agency; *Benjamin Westerhoff*, Saint Cloud State University

MPCA Stormwater Research: Understanding Contaminant Loads and Chemical-Hydrological Performance of Urban Stormwater BMPs

David Fairbairn, Minnesota Pollution Control Agency

Properties of Alternative Treatment Media for Stormwater Biofiltration Systems

David Saftner and Josh Swanson, University of Minnesota Duluth; *Meijun Cai, Kurt Johnson, and Marsha Patelke*, Natural Resources Institute, University of Minnesota Duluth

Accumulation and Transport of Road Salt in a Twin Cities Metro Lakeshed

Ben Janke, William Herb, and Heinz Stefan, Saint Anthony Falls Laboratory, University of Minnesota

Track C Rooms 1-3

Nitrate and Arsenic in Groundwater

Moderator: *Stew Thornley*, Minnesota Department of Health

Co-Moderator: *Amit Pradhananga*, University of Minnesota

Arsenic Concentration Variability in Newly Constructed Drinking Water Wells in Minnesota, USA

Melinda Erickson, United States Geological Survey Minnesota Water Science Center; *Emily Berquist*, Minnesota Department of Health; *Helen Malenda*, Colorado School of Mines

Predicting Arsenic in Drinking Water Wells in Glacial Aquifer in Western and Central Minnesota, USA

Melinda Erickson and Sarah Elliott, United States Geological Survey Minnesota Water Science Center; *Catherine Christenson*, United States Geological Survey

Time Lapse Movies of Nitrate Concentrations in Dakota County Aquifers

William Olsen, Dakota County Environmental Resources Department

The Status and Future of Nitrate in Drinking Water Aquifers

Richard Soule, Minnesota Department of Health

Track D Rooms 4-6

Flow, Floodplains, and Fish

Moderator: *Katy Thompson*, WSB & Associates

Co-Moderator: *Andrea Hendrickson*, Minnesota Department of Transportation

Using the M.O.V.E. Equations and Balances Hydrograph Analysis to Better Define Graphical Flow-Frequency Analysis

Chanel Mueller, United States Army Corps of Engineers

Managing Channel Incision Through Legacy Sediments in Driftless Area Streams

Jeffrey Lee, Ron Koth, and Jeff Weiss, Barr Engineering Company

Ecological Flow Analyses for Minnesota Streams

Jeff Ziegeweid, United States Geological Survey Minnesota Water Science Center; *Greg Johnson*, Minnesota Pollution Control Agency

Box Culvert Design to Maintain Stream Connectivity at Road-Stream Crossings

Jessica Kozarek, St. Anthony Falls Laboratory, University of Minnesota; *Jay Hatch, Britney Mosey, and Matt Hernick*, University of Minnesota

Program Schedule – Wednesday, October 18, 2017 (continued)

2:45–3:00 p.m. **Break** **Ballroom AB**

3:00–4:30 p.m. Concurrent Sessions VI

Track A Ballroom E

Keeping Stormwater on the Land

Moderator: *Jim Stark*, United States Geological Survey

Co-Moderator: *Stephanie Johnson*, Mississippi Watershed Management Organization

Water Storage that Maximizes Land Use and Production

Chuck Brandel, ISG

Water Quality Benefits of a Floodwater Storage Impoundment

Mariya Guzner and Joseph Magner, University of Minnesota; *Aaron Ostlund*, Red River Basin Commission

Water Retention for Water Quality Benefits: Targeting Practices that Improve Environmental Flows

Jun Yang, Drew Kessler, Mark Deutschman, and Tim Erickson, Houston Engineering, Inc.

Increased Precipitation as the Main Driver of Increased Streamflow in Tile Drain Watershed of the Upper Midwestern United States

Satish Gupta, Melinda Brown, Nathaniel Baeumler, and Kari A. Wolf, University of Minnesota; *William Schuh*, North Dakota State Water Commission; *Andrew Kessler*, Houston Engineering, Inc.

Track B Ballroom F

Adaptive Management

Moderator: *Marcey Westrick*, Board of Water and Soil Resources

Co-Moderator: *Gene Soderbeck*, Minnesota Pollution Control Agency

The Importance of TMDL Adaptive Management: Lessons from Shingle Creek

Diane Spector and Jeff Strom, Wenck Associates, Inc.

Minnehaha Creek Bacterial Source Identification Study—Sources of E. Coli in an Urban Environment

Michael Sadowsky and Chris Staley, University of Minnesota; *Steve Gruber*, Burns & McDonnell Engineering; *Nico Cantarero*, City of Minneapolis

Why Is Watershed Phosphorus Loading so Stubbornly Persistent?

Kelly Dooly and Yvette Christianson, Minnehaha Creek Watershed District; *Brian Beck and Joe Bischoff*, Wenck Associates, Inc.; *Eric Macbeth*, City of Eagan; *Bill James*, University of Wisconsin Stout

A Web-Based Decision Support Tool for Watershed Planning

Todd Redder, Derek Schlea, Anthony Aufdenkampe, and Hans Holmberg, LimnoTech

Track C Rooms 1-3

Measuring and Managing Altered Hydrology

Moderator: *Shawn Schottler*, St. Croix Watershed Research Station

Co-Moderator: *John Baker*, United States Department of Agriculture

Impacts of Subsurface Drainage Strategies on the Fate of Water in the Upper Midwest

Jeffrey Strock, Brent Dalzell, Axel Garcia y Garcia, Joseph Magner, Gary Sands, and Lu Zhang, University of Minnesota; *Laurent Ahiablame and Todd Trooien*, South Dakota State University

Stimulating Watershed-Scale Hydrologic Response to Farm-level Changes in Water Management

Brent Dalzell, Jeffrey Strock, Joseph Magner, and Lu Zhang, University of Minnesota

Isotope Uses in a Drained Agricultural Landscape Water Budget

Lu Zhang, Brent Dalzell, Joseph Magner, and Jeffrey Strock, University of Minnesota

Restoring Stream Flow and Reducing Groundwater Use Through Conservation Irrigation

Julie Blackburn and Paul Senne, RESPEC Consulting and Services; *Gerry Maciej*, Benton County Soil and Water Conservation District

Track D Rooms 4-6

Go with the Flow

Moderator: *Rick Voigt*, Voigt Consultants, LLC

Co-Moderator: *Ron Leaf*, Kimley-Horn & Associates

Increasing Resiliency for Flood-Prone Roadways at Henderson, Minnesota

Nicole Bartelt, Minnesota Department of Transportation; *Rachel Pichelmann*, Short Elliott Hendrickson, Inc.

Monitoring Urban Flooding—the Details that Matter: Lessons from Projects

Dan Cazanacli, Short Elliott Hendrickson, Inc.

Underwater Visualization Using 3D Sonar Equipment

Petra DeWall, Minnesota Department of Transportation Bridge Office

Innovative Technologies to Meet Changing Client Expectations in River Modeling, Bridge Monitoring, and 3D Presentation of Results

John Wirries and Kevin Pederson, KLJ Engineering

*Underline indicates onsite presenter

4:30 **Adjourn**

Poster Display

The following posters will be displayed during the breaks each day.
The poster session with poster presenters will be held on Tuesday evening, during the reception.

1. EnviroDIY open-source wireless data logging for low-cost monitoring network in the Kinnickinnic River

Anthony Aufdenkampe, LimnoTech; *Beth Fisher,* University of Minnesota; *Craig Taylor, Nick Grewe,* and *Ben Crary*, LimnoTech; *Sara Damiano*, Stroud Water Research Center; *Shannon Hicks,* Water Research Center; Friends of the Kinnickkinnic River

2. Understanding the Frequency, Distribution, and Regulating Mechanisms of Harmful and Nuisance Algae Blooms in Minnesota Lakes

Matthew Bambach, Andrew Bramburger, and *Euan Reavie*, Natural Resources Research Institute, University of Minnesota

3. Developing a Natural Resource Atlas for Northeastern Minnesota

Will Bartsch, Lucinda Johnson, George Host, Dean Peterson, George Hudak and *Richard Axler*, Natural Resources Research Institute, University of Minnesota Duluth; *Mae Davenport* and *Shannon Werbeach*, University of Minnesota; *Cynthia Hagley*, Minnesota Sea Grant

4. Improving Nitrogen and Irrigation Management for Potato Production in Central Minnesota

Brian Bohman, Carl Rosen, and *David Mulla,* University of Minnesota

5. Early Detection and Rapid Response: Developing Strategies for Invasive Phragmites in Minnesota

Julia Bohnen, Dan Larkin, and Susan Galatowitsch, Unversity of Minnesota

6. Multipurpose Drainage Management Plans: Steps to Successful Implementation

Chuck Brandel, ISG

7. Impact of Colored Dissolved Organic Matter (CDOM) on Water Treatment

Yiling Chen, Raymond Hozalski, and *William Arnold,* University of Minnesota

8. Omakakii biodiversity on the Leech Lake Reservation

Anita Cloud and Melinda Neville, Leech Lake Tribal College

9. Sediment Oxygen Demand: A Review of Current Literature and Implications for Interpretation of Water-Quality Conditions

*Erin Coenen***,** University of Minnesota, United States Geological Survey, Minnesota Water Science Center; *Victoria Christensen,* United States Geological Survey, Minnesota Water Science Center**;** *Lynn Bartsch, Rebecca Kreiling***,** and *William Richardson,* United States Geological Survey

10. Microbial Sulfate Removal in Electrode-Integrated Bioreator: Modeling and Experimental Validation

Tobin Deen, Dan Takaki and Chan Lan Chun, University of Minnesota Duluth

11. International Stormwater BMP Database: New Web-Based Tools for a Long-term Resource

Rica Enriquez, Marc Leisenring, Paul Hobson, Lucas Nguyen, Caitlin Flynn and *Daniel Pankani,* Geosyntec Consultants, Inc.

12. Antibiotic Resistant Escherichia coli (E. coli) in Minneopa Creek

Caitlin Flynn, Melissa Johnson, and Beth Proctor, Minnesota State University Mankato

13. Time-Series Data Management and Application in Watershed Projects

Lee Ganske, Brittany Story, and *Eileen Campbell*, Minnesota Pollution Control Agency

14. Cyanobacterial Harmful Algal Blooms and U.S. Geological Survey Science Capabilities

Jennifer Graham, Neil Dubrovsky, Sandra Eberts and *Victoria Christensen*, United States Geological Survey

15. Effects of Wetland Disturbance on Anuran Biodiversity Near Leech Lake Band of Ojibwe Reservation

Alana Gross and Melinda Neville, Leech Lake Tribal College

16. Contaminants of Emerging Concern Alter Fathead Minnow's Predator Escape Performance

Utku Hasbay, St. Cloud State University

17. Photodegradation of pharmaceuticals in partially nitritated wastewater

Priya I. Hora, Paige J. Novak, Melissa Jones and *William A. Arnold,* University of Minnesota

18. Escherichia coli (E. coli) Impairment in Minneopa Creek

Melissa Jones, Caitlin Flynn, and Beth Proctor, Minnesota State University Mankato

19. Is Molasses an Effective Carbon Source for Denitrification?

Elisabeth King, Lori Krider, and *Joe Magner,* University of Minnesota

20. Detecting Sulfamethoxazole and Carbamazepine in Groundwater: Is ELISA a Reliable Screening Tool?

Aliesha Krall, Sarah Elliott, and *Melinda Erickson*, United States Geological Survey; *Byron Adams*, Minnesota Pollution Control Agency

21. Novel Bioreactor Designs to Enhance Nutrient Removal

Lori Krider, Bruce Wilson, and *Joe Magner,* University of Minnesota

22. Quantifying Total Water Storage in the Minnesota River Basin

Francisco Lahoud, and *John Nieber*, University of Minnesota

23. Developing a Water Quality Risk Model for Sedimentation Due to Forest Harvesting in Minnesota

Zachary McEachran, University of Minnesota; *Robert Slesak,* Minnesota Forest Resources Council and University of Minnesota; *Diana Karwan*, University of Minnesota

24. Evaluation of Bed Load Formulas for the Minnesota River

Gustavo Merten, University of Minnesota Duluth; *Elisa Armijos,* University of Minnesota Duluth and Amazon University; *Luke Ulstad-Lisiecki*, University of Minnesota Duluth

Poster Display (continued)

The following posters will be displayed during the breaks each day.
The poster session with poster presenters will be held on Tuesday evening, during the reception.

25. Photo-production of triplet excited states in effluent organic matter

Meghan O'Connor, and *William A. Arnold,* University of Minnesota; *Douglas E. Latch*, Seattle University

26. Assessing GIS Based Tools to Target Buffer Placement for Maximum Nutrient and Sediment Removal in Southern Minnesota Watersheds

Hilary Pierce, and *Joe Magner*, University of Minnesota

27. A New Face for the Minnesota Water Research Digital Library

Stephan Roos, Minnnesota Department of Agriculture

28. Minnesota Groundwater Tracing Database

J. Wes Rutelonis, and *Betty Wheeler,* University of Minnesota; *John Barry,* and *Jeffrey Green,* Minnesota Department of Natural Resources; *E. Calvin Alexander, Jr.*, University of Minnesota

29. Comparing Shade Provided by Grassy and Woody Riparian Vegetation as a Control for Stream Temperature

Olivia Sparrow, University of Minnesota, Emmons & Olivier Resources, Inc.; *William Herb, Bruce Wilson* and *John Gulliver*, University of Minnesota

30. Aqueous abiotic reduction of munitions in iron mineral suspensions: Kinetic and compound specific isotope analyses

Jennifer Strehlau, University of Minnesota; *Bridget Ulrich,* and *Thomas Hofstetter, Bill Arnold,* University of Minnesota

31. Phosphorus Release from Urban Stormwater Retention Pond Sediments

Vinicius Taguchi, Tyler Olsen, Poornima Natarajan and *John Gulliver,* St. Anthony Falls Laboratory, University of Minnesota

32. Organohalide Respiration of Chlorinated Natural Organic Matter and its Implication for Bioremediation

Hanna Temme, and *Paige Novak*, University of Minnesota

33. Environmental Fate and Toxicity of Neonicotinoid Insecticides

Stephen Todey, William A. Arnold, and *Ann M. Fallon*, University of Minnesota

34. Saturated Buffers - Improving the site selection and design process

Nathan Utt, Gary Sands, and *Dario Canelon,* University of Minnesota

35. Wastewater Treatment Plants Engaged in Energy Efficiency (E2)

Jon Vanyo, AJ Van den Berghe, and *Karl DeWahl,* University of Minnesota, Minnesota Technical Assistance Program

36. Encapsulation of Acetogenic Bacteria in Alginate, Cell Retention and Hydrogen Production

Kuang Zhu, Craig Davis, Julian Preciado, Jonathan Sakkos, Alptekin Aksan, William Arnold, and Paige Novak, University of Minnesota

Minnesota Water Resources Conference

October 17-18, 2017
Saint Paul RiverCentre

175 West Kellogg Boulevard
Saint Paul, Minnesota

Book of Abstracts

Arranged by session in order of presentation
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Concurrent Session I, Track A

Six Mile Marsh: Total Phosphorus Sink or Soluble Phosphorus Source?

Brian Beck, Wenck Associates, Inc.; Kelly Dooley, Minnehaha Creek Watershed District; Sarah Nalven, Wenck Associates; Joe Bischoff, Wenck Associates; Anna Brown, Minnehaha Creek Watershed District

Six Mile Marsh is a ditched wetland that lies between the headwaters of Minnehaha Creek and Lake Minnetonka's westernmost bay (Halsted Bay). Historically, Six Mile Marsh has received high nutrient loads in runoff from the Six Mile Creek watershed. The traditional paradigm in wetland management for stormwater is that wetlands act as sinks of phosphorus. Over the three years studied (2013-2015), Six Mile Marsh removed an average of 115 pounds of total phosphorus (TP), which fits the traditional paradigm. However, analysis of orthophosphorus (Ortho-P) loading indicates that Six Mile Marsh exports an average of 1,295 pounds of Ortho-P. Six Mile Marsh's role as a transformer rather than a sink of phosphorus has serious implications for Halsted Bay. First, Ortho-P release occurs during the summer growing season, just as water bodies downstream are most sensitive to Ortho-P loads. So even if Six Mile Marsh is a TP sink on an annual basis, summer Ortho-P release could still result in excessive algal blooms. Second, the processes controlling settling and release of phosphorus from Six Mile Marsh are largely independent. Therefore, reducing the external TP load to Six Mile Marsh will not affect Ortho-P export from Six Mile Marsh, and reducing the sediment Ortho-P release from the wetland complex will be critical to improving water quality in Halsted Bay.

Potholes in the Prairie: Defining Wetland Complex Hydrology

Jennifer Gruetzman, United States Fish and Wildlife Service

Quantity and timing of surface water inputs to a wetland are important to maintaining wetland function and supporting the health of these vital ecosystems. The most important ecological process in maintaining a diversity of wetland habitats is the daily and seasonal fluctuations of surface water across a wetland complex. These habitats provide essential breeding grounds for wetland dependent species. It is necessary to understand the surface water dynamics of a wetland complex in order to link ecosystem function with varying wetland types. Often wetlands are defined by their vegetation and soils, but the main driver, hydrology is less understood. Therefore, in order to better understand the surface water hydrology of wetland complexes, US Fish and Wildlife Service (FWS) Hydrologists established a long-term monitoring network in 2009 that incorporated monitoring of temporary, seasonal and semi-permanent wetland types at two Waterfowl Production Areas in the Prairie Pothole Region of western Minnesota. In addition to continuous water level data, bathymetric surveys were collected for all monitored wetlands. Temporal mapping of wetland bathymetric survey data has allowed for the calculation of daily mean wetland volumes and analysis of trends over time. In addition, FWS Hydrologists have been able to quantify the extent and seasonality of wet and dry cycles based on wetland type. By quantifying depth and duration trends over time, the natural range of variability of different wetland types can be better defined. Alterations to these regimes, due to climate, land or water use change, can have detrimental impacts on sensitive wetland habitats.

Modeling hydrology of Headwater Boreal Watersheds

Jonathan Hess, Scott County Soil and Water Conservation District; John Nieber, University of Minnesota; Stephen Sebestyen, United States Forest Service

A large fraction of the runoff generated in watersheds and river basins originates in headwater areas of watersheds, and much of the biogeochemistry of watersheds is associated with processes in headwater areas. It is therefore important that the hydrology of headwater watersheds needs to be understood well. In recent discussions among hydrologists in the national and international community it is clear that headwater watersheds pose special challenges to hydrologic modelers because of the usual ephemeral character of flows generated in the headwater areas. Issues about not knowing the thresholds of when runoff begins after a period of no-flow makes it quite difficult to accurately model the outflows from such watersheds. In the present study we applied the HSPF model to a 9-ha watershed located in the Marcell Experimental Forest north of Grand Rapids. The model of the watershed was conceptualized as being composed of two subareas, the upland and the bog area of the watershed. The model was calibrated with a flow record for the period from 1990 - 1995, and validated with a flow record for the period from 1996 - 2000. NSE values for the calibration and validation were both greater than 0.80. Interesting features of threshold runoff generation in the watershed were identified in the outflow data and corresponding bog water levels. The calibrated model is currently being applied to assess the resilience of the watershed hydrologic response to projected climate change in the region.

Concurrent Session I, Track A (continued)

Monitoring Changes in Minnesota Wetland Area from 2006 to 2014

Steve Kloiber and Doug Norris, Minnesota Department of Natural Resources

The State of Minnesota has been operating a wetland status and trends monitoring program (WSTMP) since 2006. Wetland change is monitored using remote sensing data for 4,990 random plots over repeating 3-year sampling cycles. The analysis presented here includes the results from three complete sampling cycles; 2006-2008, 2009-2011, and 2012-2014. We found small, but statistically significant net gains in wetland acreages. Within the sample plots, wetland gain from 2006 to 2011 was 274 acres and wetland loss was 137 acres, resulting in a net gain of 137 acres. From 2009 to 2014, we measured a wetland gain of 547 acres, a loss of 170 acres, and a net gain of 377 acres. Extrapolating the results statewide indicates that Minnesota had a net gain of 2,330 acres (+0.018%) of wetland from 2006 to 2011 and a net gain of 6,400 acres (+0.049%) from 2009 to 2014. In spite of nominally achieving the State's no-net loss goal, the data suggest important reasons to be concerned about the state of wetlands in Minnesota. For example, much of the observed gains were unconsolidated bottom type wetlands (ponds) that typically have limited wildlife habitat value. Furthermore, there are conversions between wetland types such as emergent wetlands being converted to cultivated wetlands or unconsolidated bottom wetlands that although are not strictly speaking a loss of wetland acreage, they likely represent a loss of wetland quality.

Concurrent Session I, Track B

Performance of Iron Enhanced Sand Filters: Results from Laboratory, Urban, and Agricultural Studies

Andy Erickson and John Gulliver, St. Anthony Falls Laboratory, University of Minnesota; Pete Weiss, Valparaiso University

Iron enhanced sand filtration (IESF) is an advanced stormwater treatment practice designed to capture particulate pollutants by filtration and soluble phosphorus (phosphate) by sorption to iron oxide. In small scale laboratory tests using synthetic runoff, this technology captured nearly 90% of the influent phosphate. Subsequent full-scale installations in urban watersheds subject to natural rainfall and runoff events had phosphate capture rates ranging from 25% to 75%. These urban installations included the more common surface sand filter as well as the pond-perimeter sand filter trench. In another application, a surface sand filter was installed to treat tile drainage flow from an agricultural watershed. This site was also monitored and found to remove approximately 65% of the both influent phosphate and total phosphorus. These studies represent different applications, in different watersheds, over different segments of the lifespan of IESFs. This presentation will summarize these studies and include an analysis of IESF performance with respect to the age of the practice, influent conditions, and filter size relative to the annual inflow volume. Based on results, recommendations for different applications will be made on the sizing, expected maintenance activities and corresponding frequencies, and the expected lifespan of IESFs.

Iron Filings Application to Reduce Internal Phosphorus Loading in Lakes

Poornima Natarajan, Saint Anthony Falls Laboratory, University of Minnesota; John Gulliver, University of Minnesota; William Arnold, University of Minnesota

Phosphorus (P) cycling from lake sediments under certain environmental conditions contributes significant internal phosphorus load that impedes lake restoration efforts. To reduce algal blooms, both internal and external phosphorus loading must be addressed. In this study, addition of zero-valent iron filings to control phosphorus release from lake sediments was investigated. Sediment cores collected from two Minnesota lakes were set up for laboratory mesocosm studies to determine the effects of increasing iron supply in the sediment on P release under controlled oxic and anoxic conditions. At doses of iron greater than 0.05 g/cm2, the sediment-P flux, pore water P concentrations and water column P concentrations were found to decrease by 75 to 96%, even under anoxic conditions. The effect of iron dosing on the redox sensitive-P in the sediment was also determined. This study demonstrates that application of iron filings to lake sediments could be a potential technology for treating eutrophic lakes in Minnesota.

Using Innovative Iron Enhanced BMPs to Maximize Phosphorus Removal

Tim Olson and Bill Douglass , Bolton & Menk, Inc.

Stormwater best management practice (BMP) technology is in a state of constant evolution that is driven by the industry's rapidly increasing data collection needs, our understanding of the nature of pollutants in stormwater and the ever expanding list of degrading and impaired water resources in Minnesota. Traditional stormwater ponds and filtration BMPs are effective for removing total suspended solids (TSS). However, total phosphorus (TP) is more difficult because it includes both particulate and dissolved components. According to testing performed by the University of Minnesota, the dissolved component of the TP load averages 45% to 50% and can be as high as 95% and is particularly difficult to remove through traditional settling or filtration techniques. BMP selection is complicated when infiltration is inhibited by tight soils, high groundwater, bedrock or karst features, well head protection or space restrictions. Iron enhanced sand filters (IESF), or "Minnesota Filters" , developed by the University of Minnesota (Erickson, Gulliver 2010), is an accepted technique for targeting the dissolved fraction of the TP load. Utilizing IESF in treatment trains will result in more innovative and effective use of the expensive iron filing material, especially as we learn more about how these systems function in the field and long term maintenance requirements. This presentation will review several innovative design applications using IESF technology in varied conditions where traditional settling and filtration was not feasible. The case studies will include: - Rock Gabion Weepers with Iron Enhanced Sand Core. -Bioretention Floodplain with Perched IESF. -Multistage Tree Trench with IESF Cells. - Iron Enhanced Golf Course Sand Traps. -Infiltration Basin Lateral Flow IESF Bench.

Concurrent Session I, Track B (continued)

Iron Enhanced Sand Filter Performance for Reducing Phosphorus from a Regional Stormwater Pond: Roseville, MN

Maddie Vargo, Bob Fossum, and Britta Suppes, Capitol Region Watershed District

William Street Pond is a stormwater detention and sedimentation basin located in Roseville, MN. The pond receives stormwater from the surrounding urbanized residential neighborhood and ultimately discharges directly to Lake McCarrons, a 75-acre deep lake that supports various recreational opportunities. Capitol Region Watershed District (CRWD) regards the stormwater inputs, including particulate and dissolved phosphorus to the lake, as a high priority for stormwater improvement efforts and has implemented projects during the past 15 years to reduce incoming phosphorus loads. In 2011, William Street Pond underwent significant improvements to enhance its performance, which included an outlet retrofit with two iron-enhanced sand filter benches (IESF's). The IESF's provide the removal of dissolved phosphorus via surface sorption to oxidized iron. To assess the efficacy of the IESF's for phosphorus removal, CRWD collected influent and effluent water quality samples from 2013 to 2016. Samples were collected within 24 hours of a significant storm event to adequately capture runoff and were analyzed for multiple phosphorus species. Ninety-seven percent of samples taken during the sample period showed a reduction of total phosphorus. Similar reductions were observed for ortho-phosphate with nearly half of the effluent samples being analyzed under the method detection limit. Further, effluent samples from both filters showed very consistent, low concentrations for both phosphorus species with no correlation to influent concentrations. These results suggest that the IESF's at William Street Pond are successfully reducing the amount of phosphorus entering Lake McCarrons. Monitoring will continue at William Street Pond to further analyze the IESF's performance.

Concurrent Session I, Track C

Climate and Land Use Changes Impact on Nitrogen Concentrations and Nitrogen Loads in the Minnesota River

Nathaniel Baeumler, and Satish Gupta, University of Minnesota

Nitrogen from agricultural lands in the Midwestern United States is ending up in the Gulf of Mexico where it is resulting in hypoxic condition; affecting the fisheries and economy of the region. This study assessed the role of climate and land use changes on streamflow, baseflow (1935-2015), flow weighted N concentrations and N loads (1963-1998) in the Minnesota River at Jordan at the annual and monthly scales. This analysis was done as a step-wise regression using R Statistical package. The land use effects were simulated using the soybean area in the watershed as a surrogate. Annual analysis showed that streamflow, baseflow and N loads are controlled by precipitation of the current and past years and by current year soybean area. Past year precipitation reflects the water storage term of the water balance equation. It shows that the past year's precipitation contributes to current year baseflow as well as changes in runoff and percolation losses and thus N loads. Monthly analysis showed that besides the current and previous months' precipitations, previous year's precipitation and soybean area were also significant variables in explaining monthly stream flow, baseflow, and N loads. There was limited to no effect of these variables in explaining flow weighted N concentrations. ð ‘…2 values ranged from 0.32 to 0.89, suggesting that up to 89% of the variability in the dependent variables can be explained by precipitation and soybean area. Regression analysis without soybean area showed that soybean area explained 4 to 20 % of the variability in N loads.

Protecting Two-Story Lakes: A Battle Against Phosphorus and Climate Change

Hans Holmberg, Dendy Lofton, and Ben Crary, LimnoTech; Gary Pulford, Courte Oreilles Lake Assocation; Dan Tyrolt, Lac Courte Oreilles Conservation District

Two-story lakes in the upper Midwest support unique coldwater fisheries, including cisco, lake whitefish, and lake trout. These lakes are typically characterized by outstanding water quality. However, even modest increases in phosphorus loads, combined with longer and warmer summers, is putting a squeeze on the coldwater habitat required to sustain these aquatic life uses. Efforts to protect these lakes are critically important. This presentation will discuss the basis for and approach used to develop a site-specific phosphorus criterion (SSC) for Lac Courte Oreilles (LCO) located in Sawyer County, Wisconsin. This SSC is needed to restore and protect the highest attainable aquatic life and recreational uses for this unique two-story fishery and Outstanding Resource Water. Despite attainment of the current total phosphorus criteria (15 µg/L) in LCO, as well as meeting response criteria for chlorophyll-a, a biologic impairment exists in the lake due to depleted dissolved oxygen levels in the hypolimnion, and warmer waters in the epilimnion, resulting in reduced oxythermal habitat for the cisco and lake whitefish fishery in LCO. An extensive fish kill was experienced during late summer 2016, highlighting the need for revised criteria and additional protection efforts. A lake-wide average total phosphorus criterion of 10 µg/L is being proposed by the Courte Oreilles Lake Association (COLA) and the LCO Band of Lake Superior Chippewa Indians Conservation Department to the Wisconsin Department of Natural Resources. This paper will present the basis for the proposed SSC, including assessment of extensive monitoring data collected over the past 15 years, and recent modeling to simulate lake response to reduced phosphorus loads. Ultimately, phosphorus loading to LCO must be reduced to restore the water quality and biologic conditions in this lake. The lessons learned from the development of the SSC for LCO can be applied to other two-story lakes across the upper Midwest.

Concurrent Session I, Track C (continued)

3D Modeling and Prediction of Coolwater Fish Habitat Under Changing Climate

Shahram Missaghi, St. Anthony Falls Laboratory, University of Minnesota and University of MInnesota Extension; Miki Hondzo, and William Herb, St. Anthony Falls Laboratory, University of Minnesota

Climate change impacts the physical, chemical, and biological processes of aquatic ecosystems. Future fish habitat conditions are predicted to change both their temporal and spatial distributions. The ability to predict the fish habitat with fine spatial and temporal resolutions can facilitate and target fish management strategies that can reduce the undesirable impacts of climate change. We investigated the temporal and spatial (both vertical and horizontal) variability of fish habitat dynamics at a fine scale by using a 3D lake water quality model. We implemented a measured historical scenario and two predicted future climate change scenarios developed by applying the change fields to the two measured scenarios; results and the methods used will be presented. Water temperature (T) and dissolved oxygen (DO) were selected as key water quality parameters to evaluate the changes in coolwater fish habitat, where T increased 4 °C and DO decreases 1 mgL-1 during the ice-free seasons under the future climate scenarios. The onset of stratification increased 46 days, thermocline depth increased 64%, and the onset of anoxia occurs 4 weeks earlier. For the first time, we will report the 3D changes of T and DO defining fish habitat in a Minnesota lake. The desirable good growth fish habitat was separated for three weeks in July by the lethal fish habitat, leaving the coolwater fish with no potential refuge. The spatial and temporal prediction of stressed or lethal environmental conditions along with forecasting the potential fish refuge areas is essential in water resources and ecological management.

Engagement Strategies to Plan for Climate Resilience at the Community and Watershed Scale

Leslie Yetka, Freshwater Society; Claire Bleser, Riley Purgatory Bluff Creek Watershed District; Erica Sniegowski, Nine Mile Creek Watershed District; Fred Rozumalski, Barr Engineering Company

Current science indicates our precipitation and temperature patterns are changing in Minnesota, and will continue to do so in the future. These changes are having significant impacts on our natural resources, our built infrastructure, human health, and our societies. Freshwater Society, along with the Riley Purgatory Bluff Creek Watershed District, Nine Mile Creek Watershed District, and Barr Engineering, hosted three public engagement workshops focused on climate change, water impacts, and community resilience. These workshops were designed to 1) educate participants about climate change, local trends, and anticipated impacts, 2) use participatory mapping and engagement methods to identify local vulnerabilities and strengths to these impacts, and 3) developed prioritized community actions to build resilience. Outcomes of this work will be incorporated into municipal comprehensive plans and local surface water plans. Workshops were held in late January and early February of 2017, with four communities and one watershed in the south-west metro area. Climate related hazards, vulnerabilities, strengths, and community actions were identified related to community systems at risk, including natural resources, water infrastructure, community resources, transportation, power, and emergency response. Community actions were also analyzed for regional similarities and differences. Key findings and lessons learned will be shared.

Concurrent Session I, Track D

Sediment-Phosphorus Interactions and their Implications for Watershed Management in Agricultural Landscapes

Anna Baker, University of Minnesota; Karen Gran, University of Minnesota Duluth; Jacques Finlay, University of Minnesota; Diana Karwan, University of Minnesota; Daniel Engstrom, St. Croix Watershed Research Station, Science Museum of Minnesota; Tessa Belo, and Walter Atkins, University of Minnesota

The Le Sueur River is a deeply-incised tributary to the Minnesota River which contributes disproportionately to sediment and phosphorus loading, fueling seasonal eutrophication in downstream Lake Pepin. This study examines the role of sediment in driving watershed-scale phosphorus behavior in the Le Sueur River by incorporating sediment-phosphorus chemistry into an existing sediment budget. Total- and extractable-phosphorus and sorptive capacity were measured for source sediments from upland agricultural fields, till-bluffs, alluvial streambanks, and ravines. Preliminary results suggest that while phosphorus-rich topsoil dominates in upland river reaches, at the watershed outlet the sediment-phosphorus budget is overwhelmed by till-sediment with lower total- and dissolved-phosphorus and higher sorptive capacity. Mass-balance results suggest that the major sources of sediment to this basin may account for as little as 24% of the total-phosphorus flux through the basin, highlighting the importance of dissolved phosphorus source and transport mechanisms and the role of sorption processes in basin-wide phosphorus dynamics. Development of this sediment-phosphorus budget will be completed in fall of 2017. Due to the high affinity of phosphorus for sorption to sediment, changes in sediment loading to streams will affect phosphorus fate, transport, and retention in complex ways that must be considered in the development of watershed management strategies. Integration of sediment-phosphorus chemistry into existing models which simulate watershed response to erosion controls will help reveal how much phosphorus loss can be addressed through erosion controls alone. Furthermore, the inclusion of sediment sorptive capacity within the mass balance and modeling framework will elucidate mechanisms of phosphorus export and retention and the potential for development of legacy phosphorus stores in the Le Sueur and its downstream receiving waters.

Tackling Soluble Phosphorus in Agricultural Watersheds

Rebecca Carlson, Wenck Associates, Inc.; Cole Loewen, Clearwater River Watershed District

The Clearwater River Watershed District (District) is a 159 acre local unit of government in central Minnesota with a mix of agricultural lands and recreational lakes. The District is responsible for meeting state water quality and ecological standards in its many lakes and streams. District projects and programs target reductions in phosphorus, nitrogen, bacteria and suspended sediments. Clean water act studies have shown that for many District lakes, load reductions in soluble phosphorus are needed to meet state standards. However, removal of soluble phosphorus in runoff from large agricultural watersheds with relatively high concentrations is difficult for many reasons. The District has implemented several projects and monitored results. This paper will discuss methods used to date and their results, with attention to filter media selection, design and construction methods, applicable watershed size, inflow concentrations, results and operation and maintenance considerations. Six projects in total will be discussed, the highlighted project is the Watkins Area Storwmater Treatment Project where low flow runoff from a 7,000 acre mostly agricultural drainage area is intercepted using a weir and treated in an off-line pretreatment pond and filter system.

Concurrent Session I, Track D (continued)

Suspended-sediment Concentrations, Bedload, Particle Sizes, Surrogate Measurements, and Annual Sediment Loads for Selected Sites in the Lower Minnesota River Basin, Water Years 2011 through 2016

Joel Groten, United States Geological Survey Minnesota Water Science Center; Christopher Ellison, United States Geological Survey; Jon Hendrickson, United States Army Corps of Engineers

Sediment is the leading impairment to rivers in Minnesota. Suspended sediment in the lower Minnesota River contributes 75 to 90 percent of the sediment deposited in Lake Pepin. Accurate measurements of fluvial sediment are important for managing riverine ecosystems and commercial navigation channels in the lower Minnesota and upper Mississippi Rivers. We collected suspended sediment, bedload, and particle size data at five locations from 2011 through 2014 to understand sediment transport in the lower Minnesota River. Tributary sites at Le Sueur River and High Island Creek had higher sediment yields and suspended sediment concentrations than main stem Minnesota River sites at Mankato, Jordan, and Fort Snelling State Park. Sediment yield data indicate the reach of the Minnesota River between Mankato and Jordan is a major source of sediment. In contrast, sediment yield data indicate the reach between Jordan and Fort Snelling is a sink for sediment. Acoustic backscatter data collected from the Minnesota River at Fort Snelling State Park from 2012 through 2016 correlate strongly with physically measured suspended-sediment concentrations, suggesting that acoustic backscatter can be used as a surrogate to estimate continuous suspended sediment loads in the Minnesota River. This study improves understanding of sediment-transport relations and sediment budgets. The results of this study also demonstrate the dynamic nature of sediment aggradation, degradation, and transport in the Minnesota River Basin.

Wind Erosion: Does it Matter for Water Quality?

Kris Guentzel, Drew Kessler, and Mark Deutschman, Houston Engineering, Inc.

Excess sediment is a water quality issue in many areas across the state. While overland and near-channel erosion have been a major focus in recent years, wind erosion has gone undocumented in most sediment budget studies, leading to the question; does wind erosion matter for water quality? This issue may be of particular concern in regions with limited grade, few wind breaks, and land management activities that tend to leave soil vulnerable to erosive forces. During completion of the Lower Red River Watershed Restoration and Protection Strategy (WRAPS), wind erosion was estimated as part of a sediment budget for impaired waterways. Due to the lack of watershed-scale wind erosion assessment models, a modeling protocol was developed to estimate field losses due to wind erosion from a stratified random sample of agricultural fields using the US Department of Agriculture's Wind Erosion Prediction System (WEPS) model. Mean field losses were 4.1 tons/acre/year and were an order of magnitude larger than sheet and rill erosion estimates using other modeling technologies. This talk will explore the modeling methodology, model results, and limitations to interpreting the data (e.g. fate and transport of eroded sediment). Although it may be difficult to ascertain the full impact of aeolian sediment erosion, it cannot be disregarded from our future protection and restoration efforts in areas such as the Red River Valley.

Concurrent Session II, Track A

Predicting Responses of Lakes to Phosphorus Loading by Characterizing Efficiency of P Recycling in Sediments

Sergei Katsev, Large Lakes Observatory, University of Minnesota Duluth

This talk will show how the time scales over which the total phosphorus (TP) content of lakes responds to changes in external loadings can be estimated by charactering the recycling efficiency of P in sediments. Phosphorus commonly regulates biological productivity in lakes and internal loading of P from sediments received much attention. Yet, P fluxes from sediments and the fraction of settling P that becomes recycled back into the water column are rarely characterized. Applications of mass-balance and reaction-transport modeling techniques and sediment characterizations to lakes ranging from small lakes to Lake Superior will be described.

Assessment of Lake of the Woods' Internal Phosphorus Loading

Geoff Kramer, RESPEC Consulting and Services; Jesse Anderson, and Cary Hernandez, Minnesota Pollution Control Agency; Bruce Wilson, RESPEC Consulting and Services

Lake of the Woods (LOW) is an international water that covers 1,485 mi2 (3,846 km2) and experiences elevated phosphorus concentrations that peak with progression of the growing season generating algal blooms that may extend into the autumn. LOW is impaired by excess nutrients and a MPCA sponsored Total Maximum Daily Load (TMDL) study for the lake's Minnesota portion was initiated in 2015. This massive lake has been the subject of intense study by MPCA, Canadian provinces of Ontario and Manitoba, Canada Ministry of Environment and Climate Change, the Science Museum of Minnesota (SMM) and the International Joint Commission (IJC). The studies and projects completed include lake water quality samples, automated lake temperature/dissolved oxygen profiles (SMM), updated satellite land cover (UM), HSPF and BATHTUB modeling (RESPEC) and intensive lake sediment P studies (UW Stout). These studies have generated data necessary to develop estimates of internal loading, an important driver of LOW water quality issues but difficult to measure due to the size and complexity of this lake. Converging estimates of internal P loading (about 300 m tonnes per year) were defined by three independent studies with different methodologies: (1) temperature dependent lake sediment P release (UW Stout); (2) historical examination of lake mass balances (SMM); and (3) HSPF monthly P mass balances from the entire watershed with corresponding lake P masses (RESPEC). The results of these studies are being incorporated into discussions for future management decisions by Canadian and U.S. partners responsible for management of Lake of the Woods.

Why Zebra Mussels Are Crashing in Lake Minnetonka and What It Means for Other Lakes

Steve McComas, Blue Water Science; Eric Fieldseth, Minnehaha Creek Watershed District

Zebra mussels were first observed in Lake Minnetonka, Hennepin County, MN in 2010. The objectives of this study were to determine the influence of pre-existing algal concentrations on zebra mussel densities and impacts on water quality. Fifteen Lake Minnetonka bays were placed into 3 zebra mussel growth categories based on pre-zebra mussel chlorophyll concentrations. The 3 groups included optimal, suboptimal, and minimal growth categories. By reconstructing past whole bay zebra mussel densities we found chlorophyll and phosphorus decreased and clarity increased when zebra mussel densities reached 10 to 100 zebra mussels/m2 on natural substrates and 1,000 to 2,000 zebra mussels/m2 on seasonal plate samplers. In bays with optimal chlorophyll conditions, zebra mussels reduced chlorophyll significantly and a zebra mussel dieback occurred after 3 to 4 years of their first observation. In the suboptimal chlorophyll category, zebra mussel populations were still expanding after 7 years but at a slower rate compared to the optimal group. In the minimal growth category, zebra mussel densities have remained at low densities for 7 years, but water quality changes have still been observed in some cases. These patterns will likely be exhibited in other lakes based on pre-zebra mussel chlorophyll concentrations when calcium is not limiting for shell production.

Concurrent Session II, Track A (continued)

"Not enough evidence of a trend": Distinguishing Between Stable and Variable Water Quality

Marta Shore, James Jahnz, Lee Ganske, Shannon Martin, and Laurie Sovell, Minnesota Pollution Control Agency

At the Minnesota Pollution Control Agency, we monitor water quality parameters over time, in part, to see if increases or decreases in water quality occur. Multiple statistical tools exist (regression, Seasonal Kendall, Loess fits, time series analyses, etc.) to determine if there is a long term trend, some of which are used for the MPCA's Citizen's Monitoring and Pollutant Load Monitoring Programs. These statistical methods demonstrate if enough evidence is available or not to conclude a trend. However, not having enough evidence to conclude a trend can mean two things: either water quality is stable and consistent over the years, or the water quality fluctuates over the years but never consistently in one direction. It is important for water quality and water safety to know the difference between stable and variable water quality, even if there is no significant decrease or increase in water quality over time. Stable conditions for lakes and streams that have good water quality might suggest that watershed protection strategies are effective. Highly variable conditions emphasize the need for continued monitoring. We use current guidance and statistical theory to develop a test for stable versus variable water quality.

Concurrent Session II, Track B

Advancing Safe and Sustainable Water Reuse in Minnesota

Anita Anderson, Minnesota Department of Health

The State of Minnesota needs a comprehensive approach to water reuse, because interest in it is growing and examples are cropping up all over the state. During the 2015 legislative session, the Legislature directed the Department of Health to "prepare a comprehensive study of and recommendations for regulatory and non-regulatory approaches to water reuse for use in the development of state policy for water reuse in Minnesota." Water reuse can reduce the demand on lakes, rivers, and groundwater resources and improve water management. However, there are also potential risks to public health and the environment with reusing water. A variety of regulatory and non-regulatory approaches for reuse applications exist across the country. Minnesota needs a comprehensive, statewide approach to guide municipalities, industries, and other parties interested in implementing water reuse. An interagency team evaluated different policy, management, and design approaches for water reuse within a Minnesota context. As part of the project the workgroup completed the following: Defined the scope of reuse and identified challenges and opportunities; Analyzed existing regulatory and nonregulatory frameworks; Evaluated existing and planned reuse projects; Gathered input from stakeholders; Collaborated with University of Minnesota to research water quality in two reuse systems.; Completed an assessment of state models for water reuse management; Incorporated results from national reports on public health guidance for water reuse systems; Developed recommendations for water reuse practices and policies in Minnesota; Released a final report in summer 2017. Minnesota water agencies and utilities are also coordinating with national water reuse efforts. It is hoped that these national efforts can bring more consistency to state water reuse frameworks, making it easier for water reuse to be implemented.

Northwood Lake Stormwater Improvements

Tyler Johnson, and Chris Long, Stantec Consulting Services; Bernie Weber, and Megan Albert, City of New Hope

A case study of the New Hope Northwood Lake LID Stormwater Improvements will be presented. The goals of the project were to: (1) Improve the water quality of stormwater that previously drained untreated to Northwood Lake; (2) Minimize the impact to one of the City's flagship parks; (3) Inform and engage the Friends of Northwood Lake and surrounding neighborhood about sustainable stormwater management; and (4) Promote collaboration of stormwater management among the Basset Creek Watershed Management Commission, New Hope Public Works, and New Hope Parks Department. The project involved the planning, design, and construction of various BMPs throughout the Northwood neighborhood. A 160,000 gallon underground concrete vault collects stormwater and reuses it to irrigate ballfields. Rain gardens are provided to treat overflow from the vault. Sump manholes with skimmer structures were installed prior to the stormwater discharging into Northwood Lake. A stormwater pond along with underground trenches were installed to collect and treat stormwater runoff from the surrounding neighborhoods. The goal was to reduce total phosphorus, suspended solids, and stormwater volume to the lake. Construction in the area began in 2016 with different stages of the project continuing to occur. Most of the stormwater BMPs were completed in 2016, with the linear underground trenches being built as street reconstruction occurs. Funding was provided by the City of New Hope, Bassett Creek Watershed Management Commission, an MPCA Clean Water Grant, and a Board of Water and Soil Resources Clean Water Grant. Monitoring is being planned for the underground storage tank to determine the amount of stormwater being used to irrigate the ballfields.

Concurrent Session II, Track B

New Water Conservation Reporting System

Carmelita Nelson, Minnesota Department of Natural Resources; Leo Steidel, Energy Savings Platform

Objective: Minnesota's permitted water users move more than 475 billion gallons per year. One serious problem is the lack of a good method to measure and record whether the state is achieving water conservation goals. Based on water conservation efforts in other states, Minnesota could improve efficiency, implement reuse, and reduce water use by 20-25% with little impact to quality of life. Project Implementation: To address this problem, the Minnesota DNR will: 1) Develop a statewide Water Conservation Reporting System, 2) This system will be created by Energy Platforms who developed the Energy Conservation Improvement Program (CIP) for the MN Dept. of Commerce, 3) The project will be implemented in phases, due to the complexity of collecting data from 10,000 permittees, 4) Data from the system will be available to other agencies and researchers. Methodology: The Conservation Reporting System will provide structured data for trend analysis and robust dashboards. The system will be used by state water management agencies and legislators to make data driven policy in support of water conservation. Results: This presentation will provide details on Phase 1 including what water conservation metrics we will be collecting from cities, the nature of the data acquisition, how we went about determining the metrics, how we are developing user buy-in. Governor Dayton has deemed this the Year of Water Action, and the DNR holds this project as one of its major new initiatives. This is a rare opportunity to roll out a water conservation reporting system that will gather rich data while offering high value to the utilities.

Stormwater Reuse in Carver County: An Innovative Approach to Reducing Pollutant Loads to Water Resources

Tim Sundby, Carver County Water Management Organization

Carver County Water Management Organization (CCWMO) was established in 1996 to protect the water resources of Carver County, Minnesota. In 2012, rules for treating stormwater were updated to include a volume reduction component. Due to heavy clay soils that make up the majority of the county, stormwater reuse has become an option to meet volume standards. Regulating and monitoring stormwater reuse as a volume control BMP presents several challenges that have required the CCWMO to take innovative approaches to meet them. These challenges include correlating annual precipitation to the 0.5 inch storm event; how irrigation rates and irrigation area effects the volume credit; establishing a method for giving appropriate amount of credit based upon design criteria; transferring credits from a community reuse system to individual developments; and the effects of vegetation and soil on volume retention. To address these challenges, CCWMO has worked on better documenting the review and monitoring process including the following steps; requiring pumping meters be installed and read by CCWMO Staff; evaluation of site design criteria such as irrigation rates, dimensions and use of irrigation area, soil and vegetation types; documenting daily precipitation events; and evaluation of permitted volume credit and actual usage. To date, 14 reuse sites have been approved through our process and one regional reuse bank to offer volume credits for new development in a city. Five reuse sites started operation in 2016. A total of 2,042,762 gallons of stormwater was utilized for reuse during the 2016 season within 4 sites, which is equal to removing 10.4% of the total rainfall draining off impervious surfaces within these developments. In terms of cost, these sites had an equivalent 2016 savings of $6,593.84 in water usage rates. In addition to volume reduction, reuse removed 3.98 pounds of TP and 1,368 pounds of TSS from reaching downstream water bodies.

Concurrent Session II, Track C

Clean Water Funding and the Cost of Wastewater Treatment in Minnesota

Baishali Bakshi and Joel Peck, Minnesota Pollution Control Agency

The cost of wastewater treatment is proportionally higher for small communities typically due to lack of economies of scale in constructing, operating, and maintaining wastewater infrastructure. The high cost of wastewater infrastructure is partially mitigated by state clean water infrastructure grants awarded to communities. But have small communities received clean water grants commensurate with their needs? What are the links between clean water grant recipients, amount of grants received, population served, effluent volume treated, and utility fees across communities? In this presentation, we will analyze data over time and across regions in Minnesota to answer the above questions. Results from the analysis will facilitate greater clarity in understanding wastewater treatment needs at the community level and help incentivize cost-effective solutions for a more equitable distribution of infrastructure grants.

Nanoselenium Sponge Technology for Mercury Removal from Water

John Brockgreitens, Snober Ahmed, and Abdennour Abbas, University of Minnesota

Water pollution due to mercury contamination has been a serious problem for decades. It poses threat not only to aquatic life but also to human health as it accumulates in the food chain. In 2004, nearly 66% of the waters in Minnesota, both lakes and rivers, were designated as 'impaired' due to mercury. Over the past decades numerous methods have been employed to remove mercury from water. These include chemical precipitation, bioremediation and adsorption on materials that have demonstrated strong chemical affinities for mercury such as zeolite, selenium and thymine. Despite these efforts, current technologies are still costly when applied to the industrial scale, and there is still no available technology to remove accumulated mercury from large water bodies such as lakes. Very recently, researchers have sought to use nanomaterials, materials present in the nano-scale (10-9 m) for the direct capture of pollutants from the environment. In this report, selenium (Se) nanomaterials were directly grown on a polyurethane support to produce a mercury sorbent 'sponge' . The advantages associated with using a nanomaterial include a high surface to volume ratio, enhanced loading capacity and strong binding between mercury and the selenium nanomaterials. This sponge was able to capture 99.95% of mercury from drinking water and industrial wastewater sources with minimal interference from acids, bases and competing ions. Finally, the Se-Hg complex was found to be biologically inert exhibiting no toxicity to human fibroblast cells. This work represents a new approach to mercury capture in the environment using nanotechnology.

Rapid Removal of Phosphorus from Water using a NanoIron Sponge

Fatemeh Heidari, John Brockgreitens, and Abdennour Abbas, University of Minnesota

Excess nutrients (phosphorus, nitrogen) in water leads to algal bloom, one of the most severe problems associated with surface water. Phosphorus is the limiting nutrient to control algal growth; therefore, removing phosphates from surface water is a major strategy to prevent algal bloom in lakes and other water bodies. In this study, we present the development and evaluation of a NanoIron sponge as a phosphate sorbent. Iron nanoparticles are grown directly on a polyurethane sponge using a proprietary technology involving thermal reduction. The results demonstrate that the NanoIron sponge can remove over 99% of phosphorus from water within 5 min. After passing the solution containing 10 mg L-1 phosphorus through the NanoIron sponge, phosphorus concentration dropped to the undetectable level (μg L-1), below the US- Environmental Protection Agency (US-EPA) limit. The NanoIron sponge has an uptake capacity of over 116 mg g-1, up to 4 times the capacity of commercially available phosphate sorbents. Furthermore, the sponge exhibits antibacterial properties against cyanobacteria, which prevents biofouling and thus allows a long-term use of the sponge in real-world conditions.

Concurrent Session II, Track C (continued)

A History of "Conventional Wastewater Treatment" in Response to New Water Quality Standards in Minnesota

Kyser Scott, Minnesota Pollution Control Agency

What is "conventional wastewater treatment" in MN? The accepted definition of "conventional wastewater treatment" has varied substantially across Minnesota's history. In 1900, "conventional wastewater treatment" meant conveying raw sewage directly to the river. By the 1950s,"conventional wastewater treatment" meant settling out the raw sewage sludge before discharge. In the 1960s, the MPCA established water quality standards requiring secondary treatment and activated sludge became "conventional wastewater treatment" technology. The re-definition of "conventional wastewater treatment" has continued in response to new water quality standards ever since. This re-definition will continue into the future as we discover better how to protect water quality for public health, aquatic life and recreation. This presentation will examine how Minnesota's regulatory agencies, regulated parties and advocacy groups have re-defined "conventional wastewater treatment" over time. The presentation will examine improvements to water quality in response to new water quality standards, indexes of wastewater affordability over time and provide historical perspective on wastewater treatment improvements and water quality standards. In the future, our knowledge of environmental impacts will almost certainly outpace development of cost-effective wastewater technologies for a number of pollutants and the MPCA wants to be able to address these concerns.

Concurrent Session III, Track A

New Evidence of Algal Toxins in Lake Kabetogama, Voyageurs National Park, northern Minnesota

Victoria Christensen and Erin Stelzer, United States Geological Survey Minnesota Water Science Center; Ryan Maki, National Park Service

Harmful algal blooms are a serious problem in many Minnesota lakes. Lake Kabetogama in Voyageurs National Park is no exception, having recurring nuisance algal blooms that contain the toxin microcystin. Many of these algal blooms form in the same locations within Lake Kabetogama every year. However, due in part to the high cost of laboratory analysis, seasonal toxin data have not been available. Therefore, we collected water samples for laboratory analysis including phytoplankton identification and toxin analysis (microcystin, anatoxin-a, saxiton, and cylindrospermopsin) and measured low cost physical parameters from three sites in Lake Kabetogama from June through September in 2016-17. Quantitative polymerase chain reaction (qPCR) analyses were used to examine the DNA of the cyanobacteria and determine toxicity. Initial results indicated that microcystin concentrations were lower than previous years; however, genes were present that allow the production of saxitoxin and anatoxin-a. By sampling throughout most of the open water season, we were able to determine that some toxin producing strains were present before the blooms were visible. The on-going study will document how simple low cost parameters that are routinely measured may be used as a screening tool for prediction of toxin production and as an indication of the need for further testing.

Lake Color Across Seasons, Years, and Decades: Cross-Scale Temporal Variability in Minnesota Lake Chromophoric Dissolved Organic Matter from Field and Remote Sensing Data

Claire Griffin, Patrick Brezonik, Jacques Finlay, Leif Olmanson, Benjamin Allen, and Raymond Hozalski, University of Minnesota

Chromophoric dissolved organic matter (CDOM) varies widely in Minnesota lakes, from below detection limits to a440 ~33 m-1, appearing a dark "tea" color. CDOM represents a major fraction of the DOM pool, strongly attenuates solar irradiation, and can have direct human health implications through metals mobilization and formation of disinfectant byproducts during drinking water processes. Increases in CDOM, as have been observed in temperate and boreal lakes in the northeast USA and Scandinavia, may have thus important ecological and economic consequences. Despite its importance, we have limited knowledge of the factors controlling CDOM variability in Minnesota lakes across space and time. Here, we present field data from 2015-2017, assessing intra- and inter- annual variability in lake color across the state. Although CDOM was stable in most lakes over the course of several months, some interconnected lakes showed large changes in CDOM (>10 m-1, a440) due large storm events. Despite record rainfalls in 2016, most lakes sampled repeatedly did not vary more than a440 1-2 m-1 from year to year, except in these complex lake chains. Since historical CDOM data are not available, we used an image normalization technique and field data from 2015 to create a universal model to estimate CDOM from historical Landsat imagery in Minnesota. Variability within the record, however, may be linked to a number of processes, including: long-term climatic change, inter-annual climate variability, and watershed land use change (primarily wetland drainage), and lake connectivity. We assess these patterns of variability within a hydrologically complex and heterogeneous region of northeastern Minnesota. Preliminary work shows no increasing trends in CDOM a440 since the 1980s, in contrast to some systems in Scandinavia and the Northeastern USA.

Concurrent Session III, Track A (continued)

Moving Toward Near Real-Time Water Quality Measurements in Minnesota Using New Landsat and Sentinel Satellite Data

Leif Olmanson, Marvin Bauer, Patrick Brezonik, Jacques Finlay, Claire Griffin, Benjamin Allen, and Raymond Hozalski, University of Minnesota

Recent advances have enabled use of satellite imagery for regional scale measurements of lake characteristics beyond water clarity. The launch of Landsat 8, Sentinel 2 and 3 improved the capabilities of satellite imagery to measure chlorophyll, colored dissolved organic matter (CDOM) and suspended solids - the main determinants of water clarity. To explore the capabilities of these systems, we measured optical water quality characteristics nearly contemporaneously with satellite imagery at ~265 sites and in situ reflectance spectra at 93 sites with wide ranges of CDOM, chlorophyll, and suspended solids, the primary factors affecting reflectance. Water quality models developed for Landsat 8 data were well suited to map CDOM and water clarity while the red-edge band of Sentinel-2 also enable differentiation of inorganic particles from chlorophyll in optically complex waters. The increased spectral, radiometric, spatial and temporal resolution of these satellites enables more frequent monitoring of more properties at higher accuracy, and will enable more automated image processing. As a first step toward automation, we evaluated several image normalization and atmospheric correction methods to determine which methods provides the most consistent surface reflectance data. Using these data, we developed algorithms that can be used for similarly corrected imagery. This approach was used to create a CDOM map using Landsat 8 for > 10,000 Minnesota lakes, which was validated with in situ data. This approach will enable near real-time monitoring of water quality at regional scales, thereby enhancing our understanding of spatial and temporal variability and responses of surface waters to environmental change.

Canvasback Ducks, Wild Celery, and Nutrient Regulation in Large Shallow Water Lakes

Stephen Thomforde, Dakota County Technical College

Shallow water ecosystems represent the most functional productive ecosystems on earth, with trophic structure exceeding six levels. Tragically, many of these systems are currently impaired by excess nutrients. Efforts to restore shallow water systems need to include reducing nutrient inputs, but this premise should also consider how lakes historically regulated internal nutrient loads. This presentation sheds light on importance of identifying and restoring nutrient export mechanisms that coevolved within shallow water systems to maintain the clear-water state. The relationship between historic populations of canvasback ducks and wild celery is modeled as a nutrient export mechanism, capable of removing thousands of pounds of phosphorus and nitrogen annually from shallow water systems. A natural history of both organisms is cast, cumulating when each share the same space and time to act as a biotic control over nutrient regulation in ways that reinforced the clear-water state. Historic populations are estimated and phosphorus-nitrogen tuber content analyzed to determine nutrient export potentials. When canvasbacks where hunted into functional extinction 120 years ago, many large shallow water lakes in North America experienced eutrophication. As is the case with state transition models, a new set of biotic controls emerged that expedites nutrient input and so reinforces the impaired state. Although the canvasback wild celery relationship offered a strong control over phosphorus and nitrogen regulation, it was by no means the only control, and other potential nutrient export mechanisms are described. Several restorations tactics that maximize nutrient export from shallow water basins are described.

Concurrent Session III, Track B

Adaptive Project Execution Under Challenging Seasonal Climatic Conditions

Kyle Axtell, Rice Creek Watershed District; Dennis McAlpine, Houston Engineering, Inc.

What do you do when your project requires frozen ground conditions for access and operations? and you experience one of the warmest and wettest winters in recent history? The Rice Creek Watershed District (RCWD) faced this challenge during the 2016/2017 construction season, as it initiated the Hansen Park Comprehensive Water Management Project in New Brighton, MN. This high profile and collaborative Clean Water Fund project is providing the RCWD and its partners a unique opportunity to improve water quality in runoff to two impaired lakes, mitigate local and regional flooding, enhance wildlife habitat, and improve the aesthetics and functionality of an urban park. Project components include a first-of-its-kind Iron-Enhanced Sand Filter system, an adjustable-level dam structure, and contaminated sediment removal. RCWD's worst-case construction scenario was realized when near-record-high temperatures were logged over a sustained period during the 2016-17 winter, rendering site access infeasible. The project team scrambled to find solutions to make the most of a minimal number of cold-weather days and keep ahead of critical project deadlines. This presentation will detail the project challenges and unconventional techniques implemented to keep the project progressing while protecting downstream resources.

Solving a TMDL Problem: Keller Lake WQ Improvements

Jacob Newhall, WSB & Associates; Daryl Jacobson, City of Burnsville

The Keller Lake Water Quality Improvement Project achieves the goals of the City of Burnsville, Black Dog Watershed Management Organization, Keller Lake TMDL, and BWSR Clean Water Funds by: -Achieving the City of Burnsville phosphorus removal requirement outlined in the Keller Lake TMDL by removing approximately 78 lbs/yr; -Utilizing remaining available land to construct a high performance, regional stormwater BMP; - Providing a high-profile water resource/stormwater educational opportunity in the frequently visited Crystal Beach Park; - Retaining valuable open space in popular Crystal Beach Park by constructing the BMP underground. The innovative constructed improvements are located within Crystal Beach Park. This location contains both a 66-inch and 36-inch storm sewer that discharge untreated stormwater from 151 acres of fully developed land into Keller Lake. The trunk storm sewer systems were diverted to a treatment train consisting of pre-treatment isolator chamber with baffle walls, underground retention vault, and an active infiltration draw-down system to provide enhanced stormwater treatment. Keller Lake (DNR ID: 19-0025-00) is listed on the 303(d) Impaired Waters List for nutrient impairment. Total Maximum Daily Loads (TMDLs) were established for Keller Lake following requirements set by the Minnesota Pollution Control Agency (MPCA) to achieve the eutrophication standards. The City of Burnsville needed to reduce overall loading of total phosphorus to Keller Lake by 74 lbs annually to meet the determined TMDL of 82 lbs/yr. Phosphorus sources for Keller Lake include stormwater runoff from the watershed and internal phosphorus from the lake sediment, plant life, etc. Construction challenges will be discussed including: asbestos abatement, unidentified dump site, high groundwater levels, and contractor lessons learned will be discussed in the presentation.

Revitalizing Stormwater: Incorporating Ultra-Urban BMPs in the Jackson Street Reconstruction

Patrick Sejkora, and Chad Setterholm, Short Elliott Hendrickson, Inc.; Cindy Zerger, Toole Design Group

The City of Saint Paul's reconstruction of Jackson Street began in 2016 and is scheduled for completion Fall of 2017. The project was a major undertaking adjacent to a historic district that has undergone a recent revitalization including a new baseball park, entertainment, and both residences and businesses. Stormwater treatment for the reconstructed street surface was required by the Capital Region Watershed District. Due to the space-restrictive ultra-urban environment, myriad subsurface utilities, and concerns about infiltrated stormwater entering basements, determining the types and locations of stormwater BMPs along the project corridor was difficult. A permeable asphalt bicycle trail with porous underlying media and an underdrain was proposed along an eight block length to allow for filtration of intercepted runoff. Additionally, series of bioretention areas that include trees and water-tolerant species were designed along the northern portion of the project. The trenches utilize curb cuts to intercept runoff from the streets, while the porous media and plants within the trench help to filter stormwater before it enters drain tile connected to the storm sewer. These amenities also included streetscape features to educate the public of stormwater BMPs. The BMPs fulfilled the District's cost cap and provide a filtration volume of 40,724 cubic feet while removing 775 pounds of TSS and 2.34 pounds of particulate phosphorus annually. Despite considerable challenges, the project demonstrates urban street reconstruction projects can successfully incorporate innovative stormwater BMPs to help cities meet their stormwater management goals, enhance the urban environment, and educate the public about water resources.

Concurrent Session III, Track B (continued)

35 Years of Failures and Success: Impact of the Metropolitan Surface Water Management Act

Steve Woods, Freshwater Society

The Metropolitan Surface Water Management Act has profoundly shaped Twin Cities water management for 35 years. It's a good time for the next generation of water professionals to connect with the why and how it came to be - and be able to articulate why an awful lot of failure added up to so much success. This unique-to-Minnesota law has brought funding and focus to urban water management that has helped municipalities and watershed organizations demonstrate that an ounce of prevention does beat a pound of cure. The act is presented as a major piece of legislation that occurred within a context of the region's glacial history, Clean Water Act, 208 planning, national increase in special-purpose governments, MS4 permitting, cheaper modeling, TMDLs and the arrival of an additional million people. Information will be presented on the primary legislative author's perspectives, the churn of watershed organization formation and fatalities, and data on lake transparency, stream loading, and expenditures.

Concurrent Session III, Track C

Bioreactors and Saturated Buffer- Making an Impact on Drainage and Water Quality

Chuck Brandel, ISG

Landowners seek agricultural drainage best management practices (BMPs) that are effective at improving water quality while not taking land out of production. One practice being implemented at a growing rate is installation of bioreactors. A woodchip or denitrifying bioreactor is a subsurface structure containing wood chips as a carbon source, installed to intercept subsurface drain (tile) flow or ground water, and reduce the concentration of nitrate-nitrogen. Bioreactors provide significant water quality benefits. Bioreactors use proven technology, require no modification of current agricultural practices, and do not require land to be taken out of production. In addition, bioreactors do not decrease drainage effectiveness and require little or no maintenance which can be as simple as replacing wood chips, and they have a long anticipated lifespan of up to 20 years. Three bioreactors were installed on Faribault County Ditch 62. Timelines, budget information, funding source, and outcomes of this project are shared so others may also successfully install these practices with similar or potentially better results. Specific engineering approaches, methodologies, and techniques of project implementation and steps were taken in the approval process. Nearly a quarter of peak flow is treated by the bioreactors, and 1,800 - 2,500 pounds of Nitrate are removed annually on this 700 acre watershed. Another practice similar to a woodchip bioreactor is a saturated buffer which utilizes the natural storage within the soil profile to reduce nitrate loading. A vegetative subsurface outlet provides a route for tile drainage water to seep beneath buffer areas with perennial vegetation. This process reduces peak flow rates and nitrates in tile water, increases plant uptake of nutrients.

Nitrate Removal from Agricultural Runoff in Denitrifying Bioreactors

Nadine Hackshaw, Michael Brown, Lori Krider, Bruce Wilson, and Sebastian Behrens, University of Minnesota

Denitrifying bioreactors as nitrate mitigation strategies hold promise for improving water quality in agricultural watersheds by effectively removing nitrate through stimulation of microbial denitrification. However, managing microbial activities in engineered ecosystems based on the analyses of community composition remains challenging. A better understanding of microbial community structure and bioreactor function is required in order to optimize reactor design and management. Because functional responses of microbial communities can vary strongly depending on temperature, hydraulic residence time (HRT), and organic carbon bioavailability, an understanding of the fundamental links between population dynamics, functional resilience and community interactions in denitrifying bioreactors will improve our ability to predict and increase the stability of reactor performance. To date, only a few studies have specifically focused on the complex interplay of microbial populations and their associated functions in wood chip bioreactors. We therefore constructed sampling devices for mesoscale, laboratory denitrification bioreactors that allow spatial and temporal sampling for molecular biological analyses of microbial community composition and activity. The experimental design of the laboratory bioreactors allows for control of reactor temperature and HRT. Aim of the study is to identify parameters that affect dynamics and functional stability of the denitrifying microbial community under varying temperature and HRT that allow us to optimize and better predict reactor performance. First results show increased nitrate removal with increasing temperatures and extended HRT. Microbial community analysis utilizing functional gene based qPCR, currently underway, will help guide efforts to identify denitrifier populations associated with good and poor bioreactor performance.

Concurrent Session III, Track C (continued)

Novel Design and Field Performance of Phosphorus-Sorbing and Denitrifying Bioreactors

Andry Ranaivoson, and Jeff Strock, University of Minnesota; Gary Feyereisen, and Kurt Spokas, United States Department of Agriculture, Agricultural Research Service; Marta Roser, and David Mulla, University of Minnesota

A novel bioreactor capable of removing both nitrate-nitrogen (NO3-N) and total phosphorus (TP) was designed and tested. The prototype consisted of a 1000-L reinforced cubic tank with layers of woodchips and corn cobs for NO3-N reduction. Three materials were selected for P removal media included steel slag, crushed recycled concrete and limestone. The experimental period occurred between May and December 2016 at the Southwest Research and Outreach Center, near Lamberton, MN. The field experiment consisted of three replications of three experimental treatments. A water distribution system was constructed to divert water from a subsurface drain outlet to each of the nine cubes. Potassium acetate (CH3CO2K) was used as an external carbon source to stimulate denitrification. The experiment was divided into two phases: no acetate addition and with acetate addition. The target flow rate of subsurface drainage water delivered to each bioreactor was 4.0 L per minute (1.0 gpm). Mean discharge rates from the bioreactors was 3.5, 3.0, and 2.7 m3 d-1 for the crushed concrete, limestone, and steel slag, respectively. Hydraulic residence time ranged between 3.4 and 4.3 hour. Mean NO3-N concentration ranged from 13.1 to 13.8 mg/L at the cube outlets while that of the untreated source water averaged 19.2 mg/L. Load reduction for NO3-N ranged between 31 and 37%. Mean TP concentration ranged from 79.3 to 113.2 ug/L at the cube outlets while the source water averaged 228.5 ug/L. Total P load was reduced by between 25 and 41%.

Enhanced Microbial Sulfate Removal Through a Novel Electrode-Integrated Bioreactor

Daniel Takaki, and Tobin Deen, Natural Resources Research Institute, University of Minnesota Duluth; Daniel S. Jones, University of Minnesota; Chan Lan Chun, Natural Resources Research Institute, University of Minnesota Duluth

In northeast Minnesota, high sulfate levels in water systems is a topic of interest due to its potential adverse impacts to wild rice ecosystems. Sulfate may also contribute to methylmercury production and eutrophication in certain conditions. Increased interest has emerged for developing technologies to treat the high levels of sulfate in the circumneutral water. Biological sulfate reduction is a promising and economically viable plan for maintaining low levels of sulfate and sulfide, but its performance is highly variable. In this work, low electrical potential is applied to stimulate and sustain the process by continually supplying electron donor substrates to the sulfate reducing bacteria. Simultaneously, anodic iron dissolution from a stainless-steel electrode occurred and reacted with sulfide produced from biological sulfate reduction, to form iron sulfide. Sediment bioelectrochemical reactors were used to test the effect of low voltage on the efficacy of sulfate reduction and iron sulfide formation. Reactors contained creek sediment impacted with high strength sulfate (Second Creek, MN). Synthetic mine water with a sulfate concentration of 1000 ppm was treated within reactors operated at different voltages with control reactors (open circuit). The sulfur chemistry in the pore water of the reactors was assessed to determine microbial activity; this resulted in demonstrating active sulfate reduction occurred. Microbial community structure and relative abundance of different species associated with sulfate reduction in the reactors were examined. This study will result in a proof of concept application of electrical potential to enhance the performance of biological sulfate treatment in a controlled manner.

Concurrent Session IV, Track A

A Framework for Addressing Altered Hydrology

Timothy Erickson, Mark Deutschman, and Drew Kessler, Houston Engineering, Inc.

One of the stressors commonly referenced as a reason for aquatic life impairments is "altered hydrology." Altered hydrology is commonly thought to be characterized by increases in peak discharge and runoff volume for a range of precipitation events, as compared to some historic or benchmark condition. A challenge associated with addressing altered hydrology is the lack of a common definition, including agreement on a set of science-based metrics to establish the desired (i.e., benchmark) condition, and assess whether altered hydrology has indeed occurred. This presentation will provide a framework for defining altered hydrology through a set of ecological- and geomorphic-related metrics to quantify the level of alteration and provide information needed to set hydrologic targets. The framework relies on the statistical analysis of a long-term record of daily flow. A methodology for setting storage targets will also be discussed. A case study for the North Fork Crow River will be used as an example to illustrate the concept.

The Minnesota Public Drainage Manual - A Guide to Administrating Minnesota Statutes, Chapter 103E Publically Administered Privately Owned Drainage Systems

Tim Gillette, Minnesota Board of Water and Soil Resources

The Minnesota Public Drainage Manual (MPDM) was originally published in 1991. It was updated in 2016 and published in a wiki format on the Board of Water and Soil resources website. The MPDM has the following purposes: 1.) promote uniformity in the interpretation of Minnesota Drainage Law that is found in M.S. Chapter 103E; 2.) inform readers of the interaction between Drainage Law and other laws, state and federal; 3.) recommend uniform procedures for implementing the Drainage Law statewide; and 4.) provide standardized forms for use in drainage proceedings; 5.) provide guidance about multipurpose water management considerations and authorities; 6.) provide a chapter about drainage system best management practices (BMPs). The updated MPDM is more readable and user-friendly. The proposed presentation will go over these purposes and some examples in how they are met in the MPDM.

Improving the Effectiveness of Conservation in the Le Sueur River Basin

Amy Hansen, Saint Anthony Falls Laboratory, University of Minnesota; Christine Dolph, University of Minnesota; Efi Foufoula-Georgiou, University of California - Irvine; Patrick Belmont, and Peter Wilcock, Utah State University; Cathy Kling, Iowa State University; Jacques Finlay, University of Minnesota; Sergey Rabotyagov, University of Washington; Karen Gran, University of Minnesota Duluth; Brent Dalzell, University of Minnesota

Water quality interventions in the Le Sueur River Basin are not working. In an analysis of Clean Water Act spending over 2008 - 2015, MPCA reported that, despite spending $7 million over seven years there has been no observed decrease in sediment, phosphorus or nitrogen leaving the basin (https://www.pca.state.mn.us/water/clean-water-fund). We suggest that a watershed approach to pollutant management is needed in intensively cultivated watersheds where agriculture has changed fundamental characteristics of both pollutant inputs and hydrology throughout the watershed. In this talk, we present landscape conservation scenarios which were optimized for multiple or single pollutant endpoints, specifically sediment, nitrate and phosphorus load. Scenarios include nutrient and sediment management through; fertilizer application, tillage management, near channel & ravine stabilization, buffer strip management, cover crops, wetland restoration, and land retirement. The evaluation is based on three integrated bio-physical models, two of which were developed specifically for the Le Sueur River basin and validated with spatially extensive field sampling data. Our results show that despite distributed nutrient sources and hydrological drivers there are locations within the watershed where concentrated management interventions are most effective. We synthesize these results and provide "general rules" that could help guide effective management of key pollutants in other agricultural watersheds.

Concurrent Session IV, Track A (continued)

Evolution of the Agricultural BMP Handbook for Minnesota

Margaret Wagner, Minnesota Department of Agriculture; Christian Lenhart, and Brad Gordon, University of Minnesota; Walter Eshenaur, SRF Consulting Group, Inc.

In 2012, the Minnesota Department of Agriculture (MDA) rolled out the Agricultural Best Management Practice (BMP) Handbook for Minnesota. This comprehensive inventory of agricultural conservation practices includes definitions and examples of each practice, pollution reduction effectiveness estimates based on existing scientific literature, and economic considerations. The purpose was not intended to be a standards manual or a replacement for the NRCS Field Office Technical Guide, but rather a complimentary document providing an explanation of the research guiding practice development and implementation, as well as defining limitations. Information from the handbook has been referenced in most water quality plans and strategies, and a valuable source for identifying research gaps. The MDA observed that the user audience was broader than originally anticipated, with a high demand for updated effectiveness values for water quality model development. To address these needs, a 2017 edition was completed to incorporate recent literature, including cost data and maintenance requirements. Updates focused on revised nutrient, pest, and subsurface drainage management practices. Text was incorporated into the riparian vegetation and related chapters to ensure consistency with the new buffer rule. To emphasis the importance of realistic expectations, a chapter highlighting the variability of agricultural BMP effectiveness was developed. Additional research is necessary to identify strategies to enhance the capability of BMPs to remove soluble phosphorus, as well as furthering our understanding of the compounded benefits gained by combining BMPs. This presentation will focus on the application of the handbook to assist BMP implementation decision making for watershed planning.

Concurrent Session IV, Track B

Equity and Justice in Organizations Responsible for the Stewardship of Water Resources

Marie Donahue, and Vanessa Voller, University of Minnesota; Lark Weller, National Park Service Mississippi National River & Recreation Area

A range of organizations in Minnesota provide access to water resources, deliver water-related services to the public, or provide information on how this public good can be more effectively managed. Many of these same organizations and the water resources field more broadly struggle to ensure that this access, delivery, and information are equitably provided or that their workforce reflect the diversity of Minnesota. Organizational barriers in the water sector may sustain these inequitable outcomes and would need to be addressed to build equity and justice into how water is collectively managed. In this presentation, we provide an overview of and findings from a short-term pilot project in which we identify barriers to equity and diversity that water resource organizations in Minnesota face. This work was led by a collaborative, interdisciplinary team funded by the University of Minnesota's Office of the Vice President for Research following a Water Supply Convergence Colloquium in Spring 2016. The project team used qualitative social science research methods to explore the intersection between the topics of water and equity, conducting a series of semi-structured interviews with professionals across Minnesota knowledgeable about both water resources and equity topics. Participants were sampled from primarily public sector organizations across different scales (local, regional, state, and federal) and also represented local tribal communities, providing our project team with a range of diverse perspectives on these topics. Findings from these interviews help us identify existing barriers and provide cues for how to enhance equitable service provision of water resources in Minnesota moving forward.

What is Clean Water Worth? Accounting for the True Value of Water in Minnesota

Bonnie Keeler, University of Minnesota

Minnesota has abundant clean water resources that enhance recreation, support regional development, and promote cultural values and sense of place. However, the economic value of water remains largely invisible and as a result clean water benefits are not systematically incorporated in decisions that affect the management of our lands and water. Failure to understand the true value of clean water can place water resources at risk of overuse or result in downstream users having to "pay" for degraded water quality in terms of higher treatment costs, eutrophic lakes, or lost fish or shellfish production. How can we better account for the true value of clean water? And how can this information be used to inform policy and behavior? Drawing on research across Minnesota, Keeler will present multiple lines of evidence demonstrating how clean water affects households and communities and what may be at stake if we fail to internalize the true cost of water in decisions.

Building Capacity and Confidence: It's Not All About Money

Paul Nelson, Scott County; Mae Davenport, University of Minnesota; Troy Kuphal, Scott Soil and Water Conservation District

The terminology "building capacity" is now frequently used by water resources professionals working on local water planning and implementation, authors of this abstract included. However, the term's meaning is not clear, and it is frequently interpreted narrowly as financial or staffing capacity. This presentation will expand this interpretation with respect to accomplishing on-the-ground conservation and water resources protection and improvement, by identifying and discussing necessary capacities using a systems-thinking approach. Systems discussed will include individual, relational, organizational, and programmatic, using the author's experiences in Scott County with Sand Creek, Credit River, Cedar and McMahon Lakes, and the Multi-Level Community Capacity Model for Sustainable Watershed Management (Davenport, M.A. & Seekamp, E. (2013. A multilevel model of community capacity for sustainable watershed management. Society and Natural Resources: An International Journal, 26(9), 1101-1111.). For example, the presentation will show how the capacity for self-efficacy (i.e., belief in one's own ability) is critical for individuals to choose to take action on their properties, while an organization's capacity or skill at negotiating is central to building the trust and relationships necessary for effectively approaching landowners to implement targeted conservation.

Concurrent Session IV, Track B (continued)

Blooming Alleys for Clean Water: Addressing Impaired Waters through Citizen Engagement

Laura Scholl, and Rich Harrison, Metro Blooms

Blooming Alley projects engage neighbors in targeted areas to install stormwater BMPs on private property adjacent to alleyways, thereby transforming the ecology and function of the alley. Project goals include water quality improvements, creation of connected pollinator corridors and walkable communities. Begun in partnership with the City of Minneapolis (2014) to address the Lake Nokomis TMDL implementation plan, this program has since expanded to include projects in the Diamond Lake, Minnehaha Creek, and Crystal Lake subwatersheds and the Union Park District of St. Paul. Blooming Alleys utilizes neighbor to neighbor engagement to recruit a minimum of 30% of properties on participating blocks. Neighbors are invited to an Alley Party and design charrette by their block's Alley Captain to learn about the project and connect with neighbors. Follow-up includes technical and financial assistance to install and maintain stormwater BMPs. The program was developed in response to a social science survey and analysis of residential drainage patterns. Survey results demonstrated high water quality knowledge and desire for a neighborhood installation project. Drainage analysis showed the majority of impervious surfaces runoff to backyards and alleyways. Results to date include partnerships with 23 government and community organizations and over 300 participants and volunteers. Projects installed in 19 completed alleys include 127 raingardens, 66 native plantings, 2 infiltration columns and 91 permeable pavement systems. WinSLAMM modeling indicate projects capture 9.8 acre-feet of runoff, 14.2 lbs Phosphorus and 4,000 lbs sediment annually. Current Blooming Alley projects conclude summer 2018. Continued expansion is expected as we hear from neighborhoods and local governments interested in engaging their community in a Blooming Alleys project.

Concurrent Session IV, Track C

Simulation and Assessment of Groundwater Flow and Surface-Water Exchanges in Lakes of the Northeast Twin Cities Metropolitan Area, Minnesota, 2003 through 2013

Perry Jones, United States Geological Survey Minnesota Water Science Center; Jared Trost, United States Geological Survey; Jason Roth, United States Department of Agriculture, Natural Resources Conservation Service; Catherine Christenson, United States Geological Survey; Aliesha L. Diekoff, United States Geological Survey

The U.S. Geological Survey (USGS), the Metropolitan Council, and the Minnesota Department of Health conducted a cooperative study to assess groundwater and surface-water interactions in northeast Twin Cities Metropolitan Area (TCMA) lakes. As part of the study, a three-dimensional, steady-state groundwater-flow model representing 2003-13 mean hydrologic conditions was developed and calibrated to assess groundwater and lake-water exchanges and the effects of groundwater withdrawals and precipitation on water levels in lakes in the northeast TCMA. Lake-water outflow to simulated aquifers was a major outflow component for the four lakes simulated with the MODFLOW LAK package (Big Marine Lake, Lake Elmo, Snail Lake, and White Bear Lake), accounting for 45 to 64 percent of the total outflows from the lakes. Evaporation and transpiration from the lake surface ranged from 18 to 52 percent of the total outflow from the four lakes. Groundwater withdrawals and precipitation were varied from the 2003-13 mean values used in the calibrated model to assess the effects of groundwater withdrawals and precipitation on lake-water budgets and levels. Simulated lake-water levels and water budgets for Snail and White Bear Lakes were affected by both 5-percent changes in precipitation and 30-percent changes in groundwater withdrawals in the area, whereas the water level in Big Marine Lake was mainly affected by the 5-percent precipitation changes. The effects of groundwater withdrawals on the lake-water levels depend on the number of wells and amount of withdrawals from wells near the lakes.

Who Uses the Municipal Ground Water Supply in the North and East Ground Water Management Area?

Mick Jost, Minnesota Technical Assistance Program, University of Minnesota; Miriam Yee, Formerly Minnesota Technical Assistance Program, University of Minnesota

Industrial groundwater use in the NE GWMA is comprised of an estimated 184 facilities. Several datasets were used to investigate and review ground water use priorities in the region and six target industry sectors emerged. The largest 18 users (10% of the industrial users), use approximately 85% of the 3.5 billion gallons of groundwater. Data from regional municipalities, DNR permit information, the Met Council, location specific data, MPCA, and other on-line sources were gathered and analyzed. A data research report, and a final report were produced in 2015. Three GWMA water conservation-focused intern projects were conducted. The water saving potentials from these projects exceed 37.2 million gallons of water per year and cost savings of over $100,000 annually. In addition, the project resulted in greater accuracy in the percentage of water use attributable to classification categories, especially the water supply provided by municipalities, and a better definition of how and where industry is using groundwater in the GWMA. The project also help raise public awareness, publicize the need for water conservation, engage industry in technical assistance, and water conservation outreach including general dissemination of on-line technical water conservation information.

Concurrent Session IV, Track C (continued)

Streambank Stabilization Project: Landowner Perspectives

Barbara Liukkonen, Retired, University of Minnesota

In 2015, a streambank stabilization was installed along both banks of a 350' reach of the Stewart River, Two Harbors, Lake County, MN. The project addressed a sharp S curve in the river with undercut, slumping banks that delivered tons of clay sediment to the designated trout stream. It was funded with Legacy and 2012 Flood Recovery funds, landowner cost-share, and monies from Trout Unlimited. Reducing sediment and nutrient load, protecting Lake Superior water quality, and improving habitat were the primary goals. Construction took place in late July-early August to install two 50' stretches of toe-wood on the outside curves, two log vanes, two pools, a riffle, and a channel-side pond. The site was seeded and planted with trees and shrubs. In 2016, vegetation was planted around the pond and it was fenced. Temperature monitoring of the stream at the top and bottom of the project and of the pond was conducted during 2016 and 2017. A temperature sensor was deployed in the thalweg in the fall of 2015 and the summer of 2016. Electrofishing was conducted below the riffle area in September 2016. One log vane is working very well, but the second is not functioning as desired. There is significant scour at the downstream end of each stretch of toe-wood. The toe-wood itself is very stable and working effectively. Spring flooding in 2016 inundated the bankfull benches, which impacted survival of vegetation and washed away some of the planted trees. Some reconstruction may take place during summer 2017. As landowners we committed to in-kind and cash cost-share, planting trees and shrubs, managing invasive species, and on-going maintenance and replacement of vegetation. We experienced changes in schedule, unannounced design revisions, and challenging communications with staff from multiple jurisdictions. Professionals involved in working with landowners on cost-share projects might be interested in this landowner perspective.

Groundwater-surface Water Exchange Dynamics Following a Channel Reconfiguration Project: Stewart River, MN

Larissa Scott, University of Minnesota Duluth; Karen Gran, University of Minnesota Duluth; Lucinda Johnson, National Resources Research Institute, University of Minnesota

Little is known about how full-channel realignments alter surface-groundwater interactions, an important aspect of stream hydrology, particularly in coldwater North Shore streams that lack abundant groundwater inputs. Our primary objective is to characterize shallow surface-groundwater interactions following full-channel realignments, focusing on the Stewart River near Two Harbors, Minnesota. In late August 2015, a large construction project realigned 1,400 meters of channel, created eight floodplain ponds, and regraded 34,400 square meters. To study surface-groundwater interactions, we installed four shallow wells (0.4-1 m deep) in the disturbed floodplain and surrounding watershed and two wells along the channel above the restoration. We also installed eleven water level loggers in the realigned channel and in newly constructed ponds. A temperature logger was co-located with each of these devices to help understand surface-groundwater exchange. First year results indicate that ponds and wells located in the disturbed floodplain are closely linked hydrologically to the channel, rising and falling with little delay following a precipitation event, which is likely a function of all the unconsolidated alluvial material in the floodplain. Wells placed outside the reworked floodplain had longer recession times, indicating these areas hold water longer, and release it more slowly to the channel. Strong daily fluctuations in temperatures were observed in ponds without canopy cover and in the main channel, whereas shaded ponds and wells exhibited cooler temperatures and low to no fluctuations. Data collection will continue in summer 2018 to measure how these interactions evolve temporally.

Concurrent Session IV, Track D

Pollutant Stress in the Maumee River: Impacted Physiology and Reproduction in Fathead Minnows (Pimephales promelas) and Sunfish (Lepomis spp.)

Nicholas Cipoletti, and Heiko Schoenfuss, St. Cloud State University

Agricultural pollutants are an environmental health concern as precipitation can lead to runoff into aquatic ecosystems, resulting in stress for fish. The biological impacts of mixtures of agricultural pollutants, such as pesticides, herbicides, growth hormones, and livestock pharmaceuticals have yet to be studied. The objective of this field-based study was to assess the impact of agricultural pollutants on the physiology, reproduction, and population health of two fish species. The health of caged and resident sunfish was assessed in the Maumee River (Toledo, OH) as part of the Great Lakes Restoration Initiative. Laboratory cultured larval and adult fathead minnows were exposed for 21-days. Sunfish were analyzed for histology and hematological characteristics (VTG, glucose). Minnows were analyzed for alterations in hematological characteristics (VTG, glucose, 11-KT, E2) and reproduction. VTG concentrations in male caged sunfish were significantly higher than in resident sunfish, likely due to greater energy stores in hatchery reared sunfish. Glucose concentrations between treatments varied significantly from upstream to downstream, possibly as the result of pollutant exposure. Biological indices including body condition factor, gonadosomatic index, and hepatosomatic index of resident sunfish also differed significantly across field sites. Fathead minnow fecundity was reduced in fish exposed to environmental samples from downstream, more urbanized sites. The results indicate that agricultural pollutants entering aquatic ecosystem have an impact on fish physiology and reproduction. Further research is underway to determine whether the observed physiological impacts have any effect at the population level.

Micropollutants in Groudwater and Soil at Wastewater Land Application Sites

Sarah Elliott, United States Geological Survey Minnesota Water Science Center; Melinda Erickson, United States Geological Survey; Aliesha Krall, United States Geological Survey Minnesota Water Science Center; Byron Adams, Minnesota Pollution Control Agency

Several methods of wastewater land application, such as on-site treatment systems, are currently used in Minnesota. Wastewater discharges can contain micropollutants such as pharmaceuticals, personal care products, and other organic wastewater chemicals, which can affect soil and shallow groundwater. We evaluated the presence of micropollutants in shallow groundwater near wastewater land application sites. Three types of sites were targeted: (1) large subsurface treatment systems (LSTS), (2) rapid infiltration basins (RIB), and (3) an agricultural site that irrigates with treated wastewater. Thirty-four micropollutants were detected at LSTS and RIB sites, 18 of which were pharmaceuticals. Maximum concentrations ranged from 1.1 (glyburide) to 960 (sulfamethoxazole) nanograms per liter. Shallow groundwater, as well as soil, was sampled for micropollutants at the agricultural site. Three micropollutants were detected in groundwater, 32 were detected in soil samples. Micropollutants detected in soil included fragrances, alkylphenols, flame retardants, hormones, and antibiotics. Two antibiotics, ciprofloxacin and ofloxacin, were detected at concentrations above the limit of quantification. Results indicate that these land application methods can contribute to micropollutant loading of surface waters via groundwater discharge.

Estrone and Temperature Interactions: Effects on the Predator-Prey Relationship in Freshwater Fish

Victoria Korn, Heiko Schoenfuss, and Jessica Ward, St. Cloud State University

Contaminants of emerging concern (CECs), such as estrone (E1), have been studied extensively, however little is known about how temperature modulates the exposure effects of these compounds. Chemical exposures and temperature independently affect individual fish and their population, but little is known about their impact on predator-prey relationships. Previous studies indicate that changes arise through behavioral and physiological changes in either predator or prey. To test the effects of E1 and temperature on predator-prey relationships, adult bluegills and larval fathead minnows were exposed to E1 (125, 625 ng/L) or an ethanol control for 30 days at four temperatures (15°C, 18°C, 21°C, 24°C). Larval predator evasion performance and feeding efficiency were tested on day 21. Temperature-dependent significant differences in body length, escape angle, and total escape response were observed upon analysis of predator evasion responses. The prey catching abilities of the sunfish may have been affected, potentially mitigating the predation effects on the minnows. On day 30, predation trials were performed using one adult sunfish and a mixed group of five control and five exposed (125 or 625ng/L) larvae. The concentration-dependent survival declined for exposed larvae (125ng/L: 49.2%; 625ng/L: 52.9%) when compared to the 74.2% of control minnows in the presence of the sunfish predator. This study provides evidence that minnow populations may suffer due to impaired predator evasion performance and provides information for environmental agencies evaluating ecological effects of exogenous estrogens and climate change.

Concurrent Session IV, Track D (continued)

PFAS Trends in Environmental Media and Facility Management Considerations to Limit Future Liabilities

Shalene Thomas, Amec Foster Wheeler

Per- and polyfluoroalkyl substances (PFASs) are valuable industrial chemicals with a wide range of applications, including aqueous film forming foam (AFFF) for fighting petroleum fires. Releases of AFFF during firefighting activities or from AFFF storage areas have led to PFAS contamination of drinking water, groundwater, and surface water bodies near AFFF sources. PFAS has been found in fish tissue, and fish advisories have been put in place to limit consumption of fish, and concerns over use of contaminated surface as drinking water are possible. Amec Foster Wheeler has studied more than 100 sites across the US and has established a large and growing multi-base data set that is revealing trends in PFAS occurrence in soil, sediment, porewater, surface water, groundwater and biota. To date, literature has provided some guidance on the behavior of the chemical class in the environment as well as mechanisms of fate and transport but very little comparison has been made across an entire portfolio of sites to validate research findings or trends seen at any given site. This presentation provides both the PFAS trend analysis across media and utilizes the analysis to develop facility considerations to manage, minimize and eliminate additional environmental liabilities related to contaminated groundwater and drinking water. Several trends are presented based on the data analysis. Primary and secondary sources are defined for facility management consideration based on type of media, treatment options, and best management practices including stormwater management, wastewater treatment, biosolid management, water re-use and dewatering considerations.

Concurrent Session V, Track A

Resilience Under Accelerated Change (REACH): Modelling Tradeoffs in Water Quality, Ecosystem Services and Conservation in the Minnesota River Basin

Christy Dolph, University of Minnesota; Amy Hansen, University of Minnesota; Efi Foufoula-Georgiou, University of California - Irvine; Patrick Belmont, Utah State University; Peter Wilcock, Utah State University; Cathy Kling, Iowa State University; Jacques Finlay, University of Minnesota; Sergey Rabotyagov, University of Washington; Karen Gran, University of Minnesota Duluth; Brent Dalzell, University of Minnesota; Se Jong Cho, Johns Hopkins University

Here we present the efforts of a 5 year, multi-institution, interdisciplinary research effort, led by the University of Minnesota, to understand and predict how natural factors act together with changes in climate and human land use to affect aquatic ecosystem services in the Minnesota River Basin (MRB). The culmination of this work is a biophysical model, coupled to a holistic water quality valuation framework, that will identify the costs and benefits of conservation scenarios designed to address multiple water quality endpoints (nitrogen, phosphorus, and suspended sediment) at the scale of the entire MRB. This effort includes key biophysical processes that have previously been overlooked, such as connections between hydrology and in-channel sediment transport, and the removal of nitrogen via wetlands. Conservation management practices under consideration include fertilizer and tillage management, near channel & ravine stabilization, buffer strip management, cover crops, wetland restoration, and land retirement. Placement of conservation scenarios on the landscape are optimized for both local water quality targets (i.e., in-state water quality standards for streams, rivers, and lakes) and downstream water quality targets (i.e., nutrient and sediment reduction goals for Lake Pepin and the Gulf of Mexico). Ultimately, these conservation scenarios will include an accounting of total ecosystem benefits, including the costs and benefits to public goods such as recreation, drinking water quality, and biodiversity conservation.

Modeling Effects of Nitrogen BMPs on Nitrate Efflux from Small Agricultural Watersheds in the South Branch of the Root River Watershed

Mark Greve, John Nieber, and David Mulla, University of Minnesota; Kevin Kuehner, and Heidi Peterson, Minnesota Department of Agriculture

The objective of the work is to assess the impact of selected BMPs on reduction of nitrate export from agricultural watersheds in the South Branch of the Root River. The Minnesota Department of Agriculture has been working with producers in the South Branch of the Root River to implement BMPs that have the potential to reduce the export of nitrate from the watershed. Intensive monitoring has been ongoing since 2010 for three small watersheds (each about 4 mi2 in area) and for four field scale experiments. These watersheds and field scale experiments represent various landuse and soil/geologic conditions, ranging from upland agricultural row crop area with drained soils, to mixed agriculture and forest in hilly landscape with shallow karst. Monitoring has included continuous streamflow and meteorological measurements, and sampling for suspended sediment, phosphorus and nitrate. The SWAT model is being used as the means for evaluating potential benefits of implemented BMPs. The SWAT model has been calibrated for both hydrology and nitrate yields for two of the watersheds, and selected BMPs have been examined for the upland watershed. The BMPs examined have included nitrogen rate and fall versus spring applications. The calibration of the SWAT model for the third watershed is presently underway, and modeling of the field scale hydrology and nitrate export is expected to follow. The presentation will summarize the information about the model calibration and the benefits of the various implemented BMPs. The beneficial outcomes of the project include the evaluation of SWAT for modeling karst watersheds hydrology, and the quantification of the water quality benefits of the proposed BMPs.

Concurrent Session V, Track A (continued)

Watershed Model Calibration with HSPEXP+1.31: A case study for the Snake River Watershed

Anurag Mishra, Brian Bicknell, Paul Duda, and Tony Donigan, RESPEC Consulting and Services

Minnesota Pollution Control Agency (MPCA) has used Hydrologic Simulation Program - FORTRAN (HSPF) to develop watershed models statewide to support the Total Maximum Daily Load (TMDL) program. Calibration of watershed models involves adjustment of model parameters to match observed data, based on graphical and statistical comparisons. Model calibration also requires evaluating multiple facets of a modeling application to ensure the model simulates real world conditions as closely as possible, even if observed data is not continuously available at all monitoring locations in the watershed. Enhanced expert system for calibration of HSPF (HSPEXP+), provides a modeler not only the statistics and advice to improve the hydrology calibration of a HSPF model, it also provides reports and graphics to quickly evaluate the reasonableness and stability of the model. Since the initial release of HSPEXP+ in 2015, MPCA has funded enhancements in HSPEXP+ to improve its usability, and generate additional reports and graphs for model evaluation. A recent enhancement includes automatic creation of a specification file used by HSPEXP+ to generate hydrologic calibration statistics and parameter calibration advice. This enhancement significantly reduces the barrier for new modelers, and they can focus on the science of model calibration. HSPEXP+ also generates a suite of plots, known as "Regan Plots." These plots present information about nutrient loading rates by land use, bed sediment trend, cyclical pattern of nutrient concentration and phytoplankton growth, load duration curve for total phosphorus, etc. This research demonstrates the application of the new capabilities of HSPEXP+ with the Snake River watershed model.

Evaluating the Benefits of Cover Crop Applications on Surface Runoff, Erosion and Water Quality Using the Gridded Surface Subsurface Hydrological Analysis (GSSHA) Model

Salam Murtada, Minnesota Department of Natural Resources, Ecological and Water Resources

Discovery Farm data has previously been used to demonstrate the ability of the Gridded Surface Subsurface Hydrological Analysis (GSSHA) model to simulate the complex hydrological interactions in the surface and subsurface media at fine spatial and temporal scales. In this study, GSSHA's ability to simulate nutrient processes were explored and evaluated. Increasing soil organic content due to cover crop applications has been considered as best management practice that may provide both economic and environmental benefits. When organic matter increases, the water holding capacity of the soil increases and compaction decreases. By reducing surface run-off, cover crops allows for nutrients to become more readily available for plant uptake, which also protects the soil against excessive loss and erosion. Furthermore, the slow breakdown of organic matter by microfauna provides an on-going supply of plant available nutrients. In this study, GSSHA was used to simulate a Discovery Farm field monitored for flume flow, rainfall and water quality such as TSS, TP, DOP, NO3-NO2, NH3 and TKN. The monitoring data, over a period of five years, was used to calibrate and validate the model's hydrological responses which included sediment transport (erosion) and overland nutrient loss rates. Then the soil organic content and compaction properties were modified for successive runs to assess the potential benefits of adding cover crop to the rotation. This presentation will summarize how runoff, surface erosion and nitrogen and phosphorus loss rates were predicted to vary.

Concurrent Session V, Track B

Properties of Alternative Treatment Media for Stormwater Biofiltration Systems

Meijun Cai, Kurt Johnson, and Marsha Patelke, Natural Resources Research Institute, University of Minnesota Duluth; David Saftner, and Josh Swanson, University of Minnesota Duluth

Impervious roadways lead to an increase in runoff volume, peak discharge intensity, and stormwater runoff with accumulated pollutants. Current regulations require treatment of the first inch of highway stormwater runoff. However, water retention and pollutant removal efficiency varies significantly according to the media utilized in biofiltration systems. Current Minnesota Department of Transportation specifications utilize a mixture of organic compost and clean sand to support vegetative growth, allow stormwater infiltration, and improve water quality. The use of salvage material locally available for biofiltration media has economic benefits, but treatment performance is largely unknown. A multidisciplinary effort was conducted to determine the treatment efficiency of salvaged peat, muck, compost and taconite tailings collected from northern Minnesota in biofiltration systems. The study included investigations of soil fertility, plant growth, water infiltration and retention capacity, and pollutant removal efficiencies. Results of a series of laboratory experiments indicated that salvaged peat performed as well or better than compost as it has high moisture holding capacity, hydraulic conductivity, pollutant removal efficiency, and supports plant establishment and growth. Taconite tailings and sand have similar hydraulic and geotechnical performance, making them interchangeable from a civil engineering perspective. Taconite tailings also showed the potential to remove phosphate from water. In addition, alternative media are being tested in an ongoing field pilot experiment. Three bioslope plots containing mixtures of natural soil and compost/salvage peat as filtration materials were constructed on a slope adjacent to a parking lot to investigate water retention capacity, chemical removal efficiencies and vegetation growth.

MPCA Stormwater Research: Understanding Contaminant Loads and Chemical-Hydrological Performance of Urban Stormwater BMPs

David Fairbairn, Minnesota Pollution Control Agency

In 2015, MPCA began developing a series of stormwater research projects with Minnesota partners to investigate topics of current need and interest to stormwater professionals. Although various types of stormwater BMPs have been evolving and are known to afford water quality protection, there is a need to better understand and predict contaminant loads and fates, BMP performance and variability , and to optimize BMP designs and management techniques. To date, MPCA and our partners have implemented research projects investigating contaminant removal performance assessments of five surface or underground infiltration BMPs and five iron-enhanced sand filters, and hydrologic (infiltration) performance of five large-scale swale sites. Data collection for all of these projects spans multiple years and comprises more than 1500 samples for nutrients, metals, chloride, and/or organic compounds, plus hydrologic and contributing watershed data. Our overall goals are to enhance our understanding and use of stormwater BMPs, ensure that appropriate environmental protections are being achieved, and ensure that current and future resources are well-directed. This presentation provides an overview of the current objectives and design of MPCA's stormwater research program, specific project designs, status, and example results and analysis for projects nearing completion.

Accumulation and Transport of Road Salt in a Twin Cities Metro Lakeshed

Ben Janke, William Herb, and Heinz Stefan, Saint Anthony Falls Laboratory, University of Minnesota

The accumulation of chloride in surface waters and groundwater from road de-icing is a growing problem in many regions of the country. Work is ongoing to monitor chloride concentrations in lakes, streams, and groundwater, and to develop methods to reduce chloride usage for pavement de-icing. There is a lack of information, however, on how chloride is transported via surface runoff (or infiltrated to shallow groundwater) in the small catchments that receive road runoff, and how stormwater BMPs influence these processes. To help address this issue, we have been collecting year-round runoff and chloride data in the Lake McCarrons watershed in Ramsey County, MN, funded by the Minnesota Local Road Research Board. The monitoring sites include runoff from state highways, county roads, and city streets, and several detention ponds. Our monitoring data indicates that even in small, sewered catchments, over 50% of the applied road salt is lost to infiltration, including at sites that lack BMPs. We found the overall residence time of road salt in these small watersheds (3 - 285 acres) and ponds to be on the order of months. However, runoff in summer and autumn carried substantial chloride in some cases, including in outflow from detention ponds and a highway ditch, which we attribute to flushing of chloride retained in shallow groundwater, soils, or small ponds and wetlands.

Concurrent Session V, Track B (continued)

Assessing BMP Removal of Contaminants of Emerging Concern in Urban Stormwater

Richard Kiesling, United States Geological Survey; David Fairbairn, Minnesota Pollution Control Agency; Sarah Elliott, United States Geological Survey Minnesota Water Science Center; Mark Ferrey, Minnesota Pollution Control Agency; Benjamin Westerhoff, Saint Cloud State University

Chemicals of emerging concern (pharmaceuticals, current-use pesticides, other organic wastewater chemicals; CECs) have not been well characterized in urban stormwater. Furthermore, the ability of current stormwater best management practices (BMPs) to abate CEC loading to surface waters is not well known. We characterized the presence and concentrations of nearly 400 CECs in urban stormwater at three iron-enhanced sand filtration BMPs and three integrator outfall sites within the Twin Cities Metropolitan Area across four seasonal sampling events from February-September 2016. Detection counts ranged from 18 CECs in a BMP outflow sample to 54 in an integrator outfall sample. The median number of CECs detected in BMP inflows and integrator outfalls were similar, but detections were significantly reduced in BMP outflow samples. Reductions were observed in 83% of the paired BMP inflow/outflow samples and were accounted for by reduced numbers of current-use pesticides and other organic wastewater contaminants in BMP outflow samples. Average percent reductions in CEC detections from BMP outflows were highest in February (38%) and September (36%), and lowest in May (< 2%). Concentrations ranged from 0.63-11,600 ng/L among all sites, and total CEC concentrations were significantly reduced by BMPs. Of 48 CEC compounds with > 25% detection frequency, 19 showed significant concentration variation by site type, and 15 showed significant reductions between BMP inlets and outlets. Our results indicate that urban stormwater can be a significant source of CECs to surface water, and that iron-enhanced sand filtration BMPs can reduce some CEC concentrations depending upon season and stormwater composition.

Concurrent Session V, Track C

Arsenic Concentration Variability in Newly Constructed Drinking Water Wells in Minnesota, USA

Melinda Erickson, United States Geological Survey Minnesota Water Science Center; Emily Berquist, Minnesota Department of Health; Helen Malenda, Colorado School of Mines

The State of Minnesota revised the well code in 2008 to require testing all new potable wells for arsenic (in addition to nitrate and bacteria). The well code requires testing at a certified laboratory before the well is used as a potable water supply. However the code does not require any particular sample collection method or sampling point. To better understand the influence that sample collection methods, sampling point, and timing have on measured arsenic concentration, arsenic concentrations were measured in 250 newly constructed wells over one year in several counties known to have prevalent elevated arsenic concentrations in groundwater. Study samples were collected in the following ways: 1) total arsenic samples (unfiltered) collected by well drillers in each respective driller's common practice (from the drill rig or from plumbing); 2) initial total and dissolved (filtered) arsenic samples by MDH staff replicating driller sample timing, sampling point, and method; and 3) total and dissolved arsenic samples by MDH staff 3-6 months after well construction; and 4) total and dissolved arsenic samples by MDH staff 12 months after well construction. Initial total arsenic concentrations varied significantly from later sample concentrations, both total and dissolved. In contrast, initial dissolved sample concentration varied much less over time. Over one year, total initial arsenic samples switched between categories of above or below the 10 µg/L drinking water standard in more than 13% of wells. Dissolved arsenic samples switched between categories in only 7% of wells. Filtering initial arsenic samples reduces concentration variability over time.

Predicting Arsenic in Drinking Water Wells in Glacial Aquifer in Western and Central Minnesota, USA

Melinda Erickson, United States Geological Survey Minnesota Water Science Center; Sarah Elliott, United States Geological Survey Minnesota Water Science Center; Catherine Christenson, United State Geological Survey

Approximately 40% of available arsenic data for groundwater in western and central regions of Minnesota exceed the 10 g/L drinking water standard. However, arsenic concentrations vary considerably over short distances and regionally across the state. A boosted regression tree (BRT) model was developed to predict the probability of arsenic occurring above the drinking water standard in groundwater at typical depths used for drinking water supply in glacial aquifers in western and central Minnesota. The BRT model, using about 75 predictive factors such as well construction characteristics, glacial material characteristics, and surficial characteristics (such as soil texture, soil chemistry, or land use), predicted probabilities of elevated arsenic in well water with about 65% total accuracy. Predictive factors determined to be influential for predicted probabilities included clay gap (distance from top of screen to overlying confining unit), nearest major river (a proxy for hydrological position in the landscape), horizontal hydraulic conductivity, and distance to the top of the bedrock from the bottom of the well. For example, smaller clay gaps were typically related to higher probability of elevated arsenic concentrations. The BRT model results were then used to generate maps illustrating elevated arsenic probabilities at the depth of a typical domestic drinking water well across the modeled regions. This a first application of BRT to model elevated arsenic probabilities in a glacial aquifer system.

Time lapse Movies of Nitrate Concentrations in Dakota County Aquifers

William Olsen, Dakota County Environmental Resources Department

Time lapse movies of nitrate concentration on horizontal or vertical section lines in Dakota County aquifers are presented. The movies were made to provide visual support to water quality trend analyses in the Dakota County Ambient Groundwater Study. Nitrate was selected because nitrate concentrations are statistically correlated with other contaminants, and because large data sets of nitrate measurements were available both internally and from state agencies. Over 8500 samples from about 6000 wells were identified. A moving window interpolator in 4 dimensions: x,y,z, and time, was written in Python. The vertical and time dimensions are scaled differently from the horizontal dimensions, and the window shape is a hyper-ellipsoid. Data inside the window are weighted using the scaled Euclidian distance from the window center, and the interpolator reports the weighted mean or a weighted percentile. The method is like a LOWESS trend line, only in 4-D. It is very convenient for exploring new cross section lines, since the search radius automatically selects the relevant data. An important problem in designing the movies is to indicate the level of data support. For example, an isolated extreme data point may result in a large area being displayed with an extreme data value, yet the predictive power of a single observation is practically nil. A legend was developed using color hue for the nitrate concentration and color intensity for the data support; interpolation grid nodes with less support are colored more faintly. A concurrent plot illustrating the contributing observations can also be shown.

Concurrent Session V, Track C (continued)

The Status and Future of Nitrate in Drinking Water Aquifers

Richard Soule, Minnesota Department of Health

Many public water supply wells demonstrate a clear, increasing trends of nitrate that will exceed the MCL within 10 years. Maintaining a sustainable drinking water aquifer is a key component of wellhead protection and changes in land use are the primary tool available to public water suppliers. It is expensive to purchase the necessary area of land, risky to rely on transient agreements like CRP, and treatment costs are forever. Three categories nitrate impacted aquifers will be defined, those that have reached equilibrium, those that are moving toward equilibrium, and those that are essentially chaotic. Each of the unique wellhead protection challenges these present will be discussed. How can the critical areas where land use changes will improve water quality be identified? Will they be enough to meet the regulatory and public health demands? What will it take to prove that investments in drinking water protection are justified by their results? Regardless of whether you drink from a public or private water supply this is an impending public health challenge.

Concurrent Session V, Track D

Box Culvert Design to Maintain Stream Connectivity at Road-Stream Crossings

Jessica Kozarek, St. Anthony Falls Laboratory, University of Minnesota; Jay Hatch, Britney Mosey, and Matt Hernick, University of Minnesota

Culverts can act as barriers to fish and other aquatic organism movement in streams due to insufficient water depth, excess velocity, excess turbulence, or insufficient roughness. In addition, aquatic organisms may encounter a behavioral barrier due to different conditions (such as light) within the culvert. Culverts that act as barriers disrupt the connectivity of the movement of organisms or material (sediment transport) through a culvert and may affect the habitat conditions upstream and downstream of the culvert with excessive scour or deposition. This presentation will cover a series of experiments conducted in the field and at St. Anthony Falls Laboratory (SAFL) to examine the physical performance of fish passage culvert designs and fish behavior in dark culverts. While significant research efforts have been made to understand individual fish swimming abilities, our projects examine other aspects of fish and aquatic organism passage through culverts: a) culvert performance in terms of sediment transport into and through embedded culverts (a key component to predict habitat conditions within the culvert), b) potential behavioral barriers (light), and c) novel methods to add roughness along the boundaries of concrete box culverts. These experiments provide guidance to culvert designers on a) the need for sediment placement within embedded culverts to maintain natural stream bed roughness, b) the necessity for light mitigation strategies in long, dark culverts, and c) the ability to utilize inexpensive methods to retrofit culverts with additional boundary roughness.These experiments focus on Minnesota culvert design for maintaining stream connectivity, but lessons learned are applicable to other locations with similar geomorphic characteristics and fish communities.

Managing Channel Incision through Legacy Sediments in Driftless Area Streams

Jeffrey Lee, Ron Koth, and Jeff Weiss, Barr Engineering Company

Historic land management practices in Upper Mississippi River Valley from the late 1840s to 1950 often yielded high sediment loads from hillside and ridgeline farm fields to streams and valleys. In the Driftless Region of Minnesota, Wisconsin, Iowa and Illinois native topography and historical farming practices generated large sediment loads that were transported from upland fields to the lower valleys, resulting in several meters of sediment building up in a given valley. This legacy sediment is still impacting stream systems today through bank erosion; in many cases streams channels are incised as they have down cut through the legacy sediments but have yet to reconstruct connected and functional floodplains. For Valley Creek in Afton, MN and Pine Creek near Rushford, MN, the option to completely re-route the respective streams to re-establish floodplain connections was not available as landowner interests and other restrictions forced alternate solutions. Within this presentation we will discuss the pros and cons of different approaches utilized for floodplain reconnection, channel re-routing, raising the channel bed, and floodplain excavation. We will also discuss the landowner interests and other restrictions, including ultimate flood elevations, easement restrictions, and upstream impacts that ultimately drove the solutions for these streams.

Using the M.O.V.E equations & Balanced Hydrograph Analysis to Better Define Graphical Flow-Frequency Analysis

Chanel Mueller, United States Army Corps of Engineers

Estimation of flow-frequency relationships is an essential element of water resources planning. When flow-frequency analysis is requested at a site impacted by upstream regulation, the observed data often cannot be modeled using a statistically based distribution. Analyses must be carried out using graphical techniques. Generally, observed streamflow records only inform the peak -exceedance probability relationship up to the 2% event. Two techniques can be used to augment a graphical frequency analysis. The first technique involves extending the record using a nearby long-term site. One approach to record extension is the application of the Maintenance of Variance Equations (MOVE). Using record extension often facilitates the approximation of the 1% event. To further augment your frequency curve, synthetic balanced hydrographs can be developed using a combination of the Hydrologic Engineering Center's Statistical Software Package (HEC-SSP) and Reservoir Simulation Model (HEC-ResSIM). This technique involves producing an unregulated flow record. Analytical volume-frequency analysis is used to produce balanced hydrographs representative of extreme events for the unregulated condition. HEC-ResSIM is used to assess what impact the reservoirs would have on the balanced hydrographs to define the regulated synthetic event peaks.

Concurrent Session V, Track D (continued)

Ecological Flow Analyses for Minnesota Streams

Jeff Ziegeweid, United States Geological Survey Minnesota Water Science Center; Greg Johnson, Minnesota Pollution Control Agency

Streamflow limits the distribution and abundance of aquatic biota and regulates the ecological integrity of flowing water systems. Furthermore, streamflow alteration was identified as a key stressor on aquatic life in the Minnesota Pollution Control Agency (MPCA) Watershed Restoration and Protection Strategies (WRAPS). However, the specific aspects of streamflow alteration that affect fish and macroinvertebrate conditions in Minnesota are not well understood. The U.S. Geological Survey and MPCA conducted a study to evaluate linkages between hydrologic alteration and aquatic life condition. The EflowStats package and the R statistical environment were used to calculate 171 ecologically relevant hydrologic indices for streamgages throughout Minnesota with at least 10 years of continuous record. Calculated streamflow indices were compared among streamgages with and without previously identified trends in streamflow to determine the most significant indicators of hydrologic alteration. Statistical analyses were used to identify suitable grouping variables, such as hydrologic landscape units, level-III ecoregions, stream orders, or tiered aquatic life use classifications. In addition, subsets of the most significant indicators of hydrologic alteration were selected for each defined group of streamgages. In phase two, significant hydrologic indices will be compared to select aquatic life metrics used by MPCA to calculate fish and macroinvertebrate index of biotic integrity (IBI) scores. Streamgages and biological monitoring sites will be paired based on geographic proximity within watersheds. Statistical relations between streamflow and aquatic life condition will be used to characterize streamflow alteration as a stressor on aquatic life. Phase two will be completed in September 2019.

Concurrent Session VI, Track A

Water Storage that Maximizes Land Use and Production

Chuck Brandel, ISG

Agricultural drainage systems throughout the Midwest make up a century-old, failing infrastructure. The replacement of these systems is being met with opportunities by landowners who want to implement agricultural drainage best management practices (BMPs) that enhance crop conditions and also provide water quality benefits and protection for downstream resources. Adding storage to these systems is an extremely effective way to improve water quality by providing sedimentation treatment to runoff and drainage water. Adding storage provides other benefits including reduced peak flows, reduced flood conditions, and enhanced wildlife habitat. Understandably, landowners do not want to take land out of production so it is necessary to provide tailored approaches to water storage. Since the amount of storage can be challenging to locate and sometimes expensive due to land costs, it is important to look at water storage alternatives. Easy targets throughout watersheds can be identified and lead to compromises. A variety of engineering approaches for storage is provided through BMPs that include rate-control weirs, two-stage ditches, surge basins, wetlands, and ponds. Several case studies show results of how water storage can provide benefits to landowners and the environment through increased water quality and enhanced wildlife habitat. These water storage practices were implemented on agricultural drainage projects at Blue Earth County Ditch 57, Nicollet County Ditch 62A, Drummer Wetland Bank, CR Farms, and others. Results of these projects proved to be successful. Lessons learned from these projects may help others achieve similar or better results.

Increased Precipitation as the Main Driver of Increased Streamflow in Tile Drain Watershed of the Upper Midwestern United States

Satish Gupta, University of Minnesota; Andrew Kessler, Houston Engineering, Inc.; Melinda Brown, University of Minnesota; William Schuh, North Dakota State Water Commission; Nathaniel W. Baeumler, and Kari A. Wolf, University of Minnesota

Increased streamflow and its associated impacts on water quality have frequently been linked to Land Use and Land Cover (LULC) changes such as increased tile drainage, cultivation of prairies, and adoption of soybean (Glycine max) in modern day cropping systems. However, recent analysis of streamflow records from 29 HUC 8 watersheds in Iowa and Minnesota showed climate instead of LULC change was the major driver of increased streamflow. The analysis was done through comparison of annual streamflow vs. annual precipitation relationships for the pre-change and post-change periods. A statistical shift in annual relationships from the pre- to post-change period was assumed to be an indication of LULC changes whereas a lack of statistical shift suggested no change in the relationship and higher flows were mainly driven by increased precipitation. In this paper, we further show that annual streamflow and base flow were influenced by precipitation in the preceding one to two years and this effect is manifested through increased or decreased soil moisture/soil storage. We also show that changes in monthly streamflow hydrographs are linked to soil wetness through the preceding months - and years - precipitation. Further through comparisons of the slope of the rising and falling limbs of the daily hydrograph between the pre-change and post-change periods, we show no discernable effect of LULC changes in the connectivity and retentive capacity of the Redwood River watershed. These evaluations at three different temporal scales support our earlier conclusions that increased precipitation and not LULC changes in recent years is the main driver of the increased streamflow in tile drained watershed of the upper Midwestern United States.

Concurrent Session VI, Track A (continued)

Water Quality Benefits of a Floodwater Storage Impoundment

Mariya Guzner, University of Minnesota; Aaron Ostlund, Red River Basin Commission; Joe Magner, University of Minnesota

The water quality benefits of a floodwater storage impoundment in the Red River Basin, MN, were tested through various methods. There are several dozen similar impoundments in the state already and plans to build approximately 200 in total; the impoundments are a tremendous resource because they can capture and store nutrient pollutants and suspended sediments and consequently improve downstream water quality. Results of this research are intended to advise management of the study site and, similar impoundments and constructed wetlands, for water quality treatment. Nutrient budgets were built for the impoundment in 2014, 2015 and 2016. Load and concentration reductions were calculated, for water entering and leaving the system, for nitrogen, phosphorus and total suspended soils. In 2016, nitrogen and phosphorus reductions of 73% and 66%, respectively, were achieved. A hypothetical load reduction calculation was also modeled, to determine the effects of impoundment water draw-down speed on pollutant capture. The soil phosphorus storage potential of the impoundment was determined through a laboratory sorption experiment. Soils at the site were analyzed for their linear adsorption coefficient (K) and equilibrium P concentration at zero-sorption (EPC0). Analysis compared soils under various land uses, including: cropped, planted with native vegetation, and flooded. Results suggest that all soils within the impoundment outperform soils at the exterior of the structure, in terms of phosphorus storage and buffering potential. Variation in soil-phosphorus sorption properties between sites with different vegetation types may advise cropping and planting plans to optimize water quality benefits.

Water Retention for Water Quality Benefits: Targeting Practices that Improve Environmental Flows

Jun Yang, Drew Kessler Kessler, Mark Deutschman, and Tim Erickson, Houston Engineering, Inc.;

Environmental flows are necessary to maintain the health and stability of aquatic ecosystems. Numerous waterways across Minnesota have been identified as impaired for aquatic life, often due to stress caused by alterations in environmental flows. As techniques emerge to set management goals based upon metrics (e.g., baseflow, volume, peak discharge) that provide environmental flows, conservation efforts will need to be targeted not only for treatment of pollutants at the practice, but also for management of water for downstream environmental flows and aquatic ecosystem health and stability. This presentation will demonstrate a new hydrologic routing tool for targeting conservation efforts for multiple benefits including treatment of water at the practice, management of water to improve environmental flows for downstream riparian ecosystems, and opportunities to increase flood resiliency through traditional water quality conservation efforts. Case studies will be shown from multiple agro-ecoregions across Minnesota where this new technique has been applied.

Concurrent Session VI, Track B

A Web-based Decision Support Tool for Watershed Planning

Anthony K. Aufdenkampe, Derek Schlea, Anthony Aufdenkampe, and Hans Holmberg, LimnoTech

As part of its pledge to aid in the cleanup of Vermont's streams and lakes, Keurig Green Mountain contracted LimnoTech to develop the Clean Water Roadmap tool (CWR) for Vermont, a web-based tool designed to support basin planning efforts led by the Department of Environmental Conservation (DEC) to address the phosphorus TMDL for Lake Champlain and to promote conservation of wetlands and other natural assets. The CWR tool allows DEC planning staff to identify: 1) high-priority catchments and land areas for phosphorus reductions and conservation, and 2) specific management practices that would be most cost-effective in reducing phosphorus loading to Lake Champlain. The benefits of this tool include: incorporation of SWAT model results informing watershed loadings; interactive, map-based web deployment to support Vermont's basin management planning efforts aimed at meeting load reductions specified under the Lake Champlain phosphorus TMDL; and collaboration with The Nature Conservancy to integrate their Water Quality Blueprint into the web-based tool to promote conservation efforts. A public roll-out and training for DEC staff was conducted in late March 2017, and the outreach version of the Clean Water Roadmap is available to the general public at the following address: https://anrweb.vt.gov/DEC/CWR/CWR-tool. Development of this tool to support the One Watershed One Plan efforts across Minnesota shows great potential. The strengths of this approach include: web-deployment that provides access to anyone, anytime; fully leveraging the investments made in the HSPF modeling across the state; combining other prioritization and targeting efforts such as MDNR's WHAF; utilizing load reduction estimates from multiple sources to quantify measurable benefits; and tracking BMPs during the planning process as well as the throughout the 10-year watershed planning cycle.

Why is Watershed Phosphorus Loading so Stubbornly Persistent?

Joe Bischoff, Wenck Associates, Inc.; Eric Macbeth, City of Eagan; Kelly Dooley, Minnehaha Creek Watershed District; Yvette Christianson, Minnehaha Creek Watershed District; Brian Beck, Wenck Associates, Inc.; Bill James, University of Wisconsin - Stout

The traditional paradigm for reducing phosphorus loading from watersheds is to build or utilize nutrient sinks by settling phosphorus in stormwater ponds and wetlands. One of the primary assumptions in this approach is that phosphorus is permanently sequestered once the phosphorus settles and reports to pond or wetland sediments. Recent evidence for both stormwater ponds and wetlands suggest that sediments expected to permanently sequester the phosphorus are becoming saturated and are releasing phosphorus to surface waters, offsetting any new efforts aimed at reducing watershed phosphorus loading. Further exacerbating the problem, phosphorus released from sediments is in dissolved forms that are not removed by traditional practices and can directly result in excessive algal blooms. Wenck analyzed ponds and wetland sediments from watersheds in the Twin Cities Metropolitan Area that receive stormwater to characterize their potential to release previously sequestered phosphorus into surface waters. Results of these studies demonstrate that many sediments are high in mobile phosphorus and have the potential to offset watershed nutrient reduction efforts. Management and modeling approaches will be discussed to address this 'legacy'phosphorus in stormwater ponds and wetlands.

Minnehaha Creek Bacterial Source Identification Study - Sources of E. coli in an Urban Environment

Steve Gruber, Burns & McDonnell Engineering; Nico Cantarero, City of Minneapolis; Michael Sadowsky, and Chris Staley, University of Minnesota

Minnehaha Creek is a 22-mile long urban stream in Hennepin County, Minnesota that flows through the southwestern Twin Cities area. A total maximum daily load (TMDL) has been established for the creek due to elevated levels of Escherichia coli (E. coli). In response to the TMDL, the City of Minneapolis initiated this bacterial source identification study to identify the sources of E. coli in the creek and the surrounding watershed. A multiple lines of evidence approach was used to identify E. coli sources, which included baseline monitoring, sanitary surveys, groundwater characterization, bacterial regrowth assessments, and a series of special studies. A suite of tools was used for the studies, which included traditional culture techniques, genetic molecular markers, and microbial community analysis. The results indicated that concentrations of E. coli in the creek are heavily influenced by flow regime in this highly managed system. Sources of E. coli included bird and (to a lesser extent) dog feces, regrowth of bacteria in the storm drains, soil and organic debris in the watershed, and sediment and soil in the streambanks and surrounding riparian area. Meaningful levels of E. coli from human origin were not identified. The extent to which the sources influenced concentrations in the creek receiving waters was highly dependent on the transport mechanisms and the creek's flow regime. Best management practices to reduce E. coli concentrations in the creek are currently being evaluated by the City.

Concurrent Session VI, Track B (continued)

The Importance of TMDL Adaptive Management: Lessons from Shingle Creek

Diane Spector, and Jeff Strom, Wenck Associates, Inc.

Total Maximum Daily Loads (TMDL) are waterbody diagnostic studies performed as a snapshot in time, often completed using general assumptions and a limited set of data. Adaptive Management is a critical component of TMDL implementation to "course correct" as more data becomes available and as implementation proceeds. The Shingle Creek Watershed Management Commission built into its 13 lake and 6 stream TMDLs and its Watershed Management Plan a systematic plan to collect more data and every five years review progress toward meeting the TMDL goals. Some surprising results have come from the reviews completed to date and show how critical these reviews and Adaptive Management are to ensuring stakeholders are moving continuously along the right path. We will present three of those reviews. In the first case, new inflow and lake sediment core monitoring data revealed that nutrient loading from the lakeshed was less significant to lake water quality than was assumed in the TMDL, and that internal sediment release was likely greater. Implementation actions are now being reprioritized based on these findings. A second five year review of a stream impairment confirmed that progress was being made to implement BMPs and achieve load reductions, but established realistic interim goals for focus in the coming years. The third lake TMDL review documented actions and progress, and affirmed that two of four lakes in a chain had improved enough to be delisted. Active Adaptive Management is critical to achieving better success at meeting TMDL implementation goals.

Concurrent Session VI, Track C

Restoring Stream Flow and Reducing Groundwater Use through Conservation Irrigation

Julie Blackburn, RESPEC Consulting and Services; Gerry Maciej, Benton County Soil and Water Conservation Districts; Paul Senne, RESPEC Consulting and Services

Irrigation using groundwater exceeds or is approaching sustainable thresholds in many areas across the United States. Little Rock Creek is one of four DNR groundwater management areas in the state. This groundwater fed, cold-water, trout stream is impaired due to a lack of coldwater fish assemblage, low dissolved oxygen, and excess nitrogen. Restoration efforts focus on reducing groundwater use to improve base flow conditions in the creek. Reducing groundwater use through conservation irrigation is the focus of this Environment and Natural Resource Trust Fund (ENRTF) project. Most conservation irrigation scheduling tools available are outdated and no longer effective in meeting resource management needs. This project consists of developing an open source, web-based, mobile irrigation scheduling application that also provides users with real-time information on stream conditions and regularly updated information on groundwater levels. For each user's agricultural field, the system calculates soil water holding capacity, collects weather data, and calculates the crop-specific recommended irrigation timing and volumes on a daily basis. Irrigators can quickly view the status of their fields and schedule irrigation based on recommendations. Stream and groundwater status indicators provide users with information on current conditions and recommendations for additional conservation measures as the resource conditions change. The application is in the second season of use. It has been well received and improvements continue to be made based on user feedback. The project also includes transferring the technology to another area in Minnesota to expand the adoption of conservation irrigation and reduce irrigation impacts on groundwater levels.

Simulating Watershed-Scale Hydrologic Response to Farm-Level Changes in Water Management

Brent Dalzell, Jeff Strock, Joe Magner, and Lu Zhang, University of Minnesta

In landscapes dominated by row-crop agriculture, changes to management practices at the farm-scale can potentially result in watershed-scale responses to hydrology. However, quantifying these responses can be difficult because management impacts are superimposed upon spatial variability of landscape characteristics and temporal variability of weather. We conducted a watershed-scale modeling approach in order to understand how watershed-scale hydrology may respond to farm management. Farm-scale hydrology in the model is being validated and constrained by field observations of crop growth, soil water content, and water source and residence time (determined via 3H and 18O isotopes). Preliminary model results from the Cottonwood River Basin suggest that surface runoff makes an important contribution to peak flow following precipitation events but that flow from subsurface tile drainage comprises roughly two thirds of total water yield and tile flow is often the main component of stream flow. Ongoing analyses are focused on quantifying how these relationships may change under scenarios of changing management and weather.

Impacts of Subsurface Drainage Strategies on the Fate of Water in the Upper Midwest

Jeffrey Strock, University of Minnesota; Laurent Ahiablame, South Dakota State University; Brent Dalzell, Axel Garcia y Garcia, Joseph Magner, and Gary Sands, University of Minnesota; Todd Trooien, South Dakota State University; Lu Zhang, University of Minnesota

Land use and management for agricultural row crop production have been implicated in the alteration of surface and groundwater hydrology and water quality. What remains poorly understood, however, is the influence of agricultural management practices on field and landscape-scale water budgets. The overall objective of this research was to quantify the impact agricultural drainage strategies have on water budgets of corn production systems with and without subsurface drainage. Field research was conducted at three sites that extend along a west-east precipitation gradient from eastern South Dakota to south-central Minnesota. Average annual precipitation for the study sites ranges from approximately 584 mm in eastern SD to over 762 mm for south-central MN. Direct and indirect determination of soil water balance components were obtained along with plant metrics (e.g. root length density, leaf area index, yield). Agricultural water balances were compared with local/regional baseline perennial vegetation water balances. Preliminary results indicate that year-to-year climate variability and subsurface drainage strategies affect individual components of the water balance. Results of this research will provide important information that will allow farmers, land managers and water management system designers to develop water management infrastructure in a way that is both effective for production and environmentally responsible.

Concurrent Session VI, Track C (continued)

Isotope Uses in a Drained Agricultural Landscape Water Budget

Lu Zhang, Brent Dalzell, Joe Magner, and Jeffrey Strock, University of Minnesota

Drainage is a common agricultural management practice. Implementation of drainage alters the timing and duration of subsurface discharge of water through drain tiles. Drainage directly alters soil water content in the root zone and indirectly affects other parts of the local hydrologic cycle. This study specifically looked at hydraulic residence time (HRT) component of the field hydrologic storage for different water sources. These include soil water, shallow well, deep well, tile and river. Field research sites were (from west to east) Beresford, SD, Tracy, MN, and Waseca, MN. Local meteoric water lines were established for each field location. Hydraulic residence time was estimated using seasonal variations of isotope 18O in precipitation and well-mixed receiving waters. For groundwater HRT estimation, tritium was also used, which appeared to represent the groundwater HRT better than 18O. In addition to HRT estimation, 18O was also used as a conservative tracer for hydrograph separation. As part of the hydrologic impact research, this study will aid in quantifying field water budgets for drained agricultural landscapes and provide information for computer model simulation.

Concurrent Session VI, Track D

Increasing Resiliency for Flood-Prone Roadways at Henderson, Minnesota

Nicole Bartelt, Minnesota Department of Transportation; Rachel Pichelmann, Short Elliott Hendrickson, Inc.

The community of Henderson is located along the Minnesota River about one hour southwest of the Twin Cities. While the river offers recreational and aesthetic benefits, it has also caused substantial damage during floods. Over the past twenty five years, MN Trunk Highway 19 at Henderson has been closed nine times (for a total of more than 180 days) due to flooding on the Minnesota River. Two other major roadways into Henderson have experienced similar flooding, significantly restricting access to and regional travel through Henderson during floods. With the average daily cost of closure nearing $90,000, the need to reduce the flood risk of these major highways was evident. For each roadway, a preferred alternative was developed to satisfy the project goals of reducing roadway closure frequency and duration, while not impacting river stages on the Minnesota River. To ensure each alternative satisfied the 'no rise' design criteria, a 1D HEC-RAS model was used as a cursory evaluation tool, and an SRH-2D model was developed to perform advanced analysis. The SRH-2D model was a critical component of the analysis, as the results indicated the need for additional mitigation measures which otherwise may have been excluded. By incorporating 2D hydraulic modeling into the process, this study aligns well with the objectives of the recently implemented FHWA CHANGE program. This study is currently underway, but will be completed prior to the date of the conference.

Modeling Urban Flooding - The Details that Matter: Lessons from Projects

Dan Cazanacli, Short Elliott Hendrickson, Inc.

Identifying the causes of and potential solutions to urban flooding, requires a regional analysis that may include depictions of large storm sewer networks and complex overland runoff routing. A common trend is to use a specialized storm water modeling software such as XPSWMM to build a detailed routing model that includes the entire storm system or at least every manhole and partition the drainage area into hundreds of subcatchments. Such level of detail, however does not necessarily translate into better predictions. In some cases the details could in fact result in distorted predictions. Three project examples, one in Woodbury and two in Minneapolis, illustrate how sometimes it is preferable to escape a very large model, in favor of a simplified analysis, that captures not fewer details that actually matter. One case, a flooded road, illustrates how a most of large watershed scale model can be safely cropped out without any impact on the area of interest. Another case, assessing the potential for flooding of a highway section shows how a simplified representation of the very large storm sewer network, which retains only the main pipes, can yield significantly better results, validated by comparison against documented rainfall events. The third case, shows how sometimes the details could be quite important but the details that matter, however, are less related to the extent of the model but rather consist of a faithful description of the surface runoff and each storm inlet point at the area of interest. In sum, when analyzing complex systems, a detailed model with thousands of data points is no sure recipe for improved predictions. Instead it could hamper the understanding of the runoff routing and what flooding assessment. Conversely, a simplified model skips many details that are marginally important but it reliably captures the essential processes and the overall dynamic, making better flooding predictions.

Underwater Visualization Using 3D Sonar Equipment

Jon Vanyo, Minnesota Department of Transportation Bridge Office

The inability to see underwater has long been a problem for bridge owners. Divers have been used in the past to try to determine if a structure has issues but a lot of these inspections are done by 'feel' due to the clarity of the water. Underwater Bridge Inspection by divers are routinely done on bridges over water every 4 years. The inspections will let a bridge owner know if there is a problem, but measuring the extent of the problem can be difficult. Sonar has been used in the past to document problems to structures in coastal areas, but little has been done in a riverine environment. MnDOT recently obtained 3D sonar equipment to assist in underwater inspections. The equipment can generate a 3D point cloud of an underwater structure that can then be used to measure any extent of damage. We are finding a variety of uses for the equipment such as imaging underwater structures to see how extensive damage is, post construction scans to make sure the contractor did't leave debris in the water body, baseline measurements on structures in areas where scour has been an issue in the past and extremely detailed river bottom mapping. The 3D equipment will never replace divers as the sonar device has limitations but it can give you a quick assessment of a problem. We feel that imaging is a great first step in diagnosing an underwater problem with a structure and gives divers necessary information so they can concentrate on the area of concern identified with the scan.

Concurrent Session VI, Track D (continued)

Innovative Technologies to Meet Changing Client Expectations in River Modeling, Bridge Monitoring, and 3D Presentation of Results

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On February 2, 2017, the MnDOT Bridge Office announced their shift to 2D modeling for their bridges along with expressing State pursuit of the FHWA "Every Day Counts (EDC)" program; a limited switch to 2D modeling and 3D graphic visualization. KLJ will discuss how we have anticipated this change in expectations in terms of project objective, engineering approach, innovative technologies and better communication of results. A bridge near Williston, ND over the Missouri River in 2012. 1D methods were first employed but were unable to adequately describe complex overbank flow paths. 2D technologies allowed the NDDOT better representation. Valley City, ND is conducting ongoing construction of permanent flood protection, remapping the floodplain and improving interior drainage. KLJ is using lidar, augmented with survey, and sonar bathymetry into integrated 1D/2D models with XPSWMM and HEC-RAS to better analyze and map river floodplains and interior drainage. KLJ will demonstrate dynamic 3D graphical representations of the city with incorporated results. Commencing in 2017, monitoring the Main Avenue Bridge - Fargo, ND/Moorhead, MN to look for bridge movement. Employing point clouds of the bridge to show to centimeter accuracy the location of the bridge in 3-Dimensional space. KLJ will conclude with discussions regarding future directions for fully integrated projects using these technologies, with additional dynamic 3D representations, leading to enhanced results, and better communications of engineering designs to agencies and the public.

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